

Date: February 12, 1999

09/242383

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**TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 USC 371**

International Application No.: PCT/GB98/01717  
International Filing Date: June 12, 1998  
Priority Date Claimed: June 13, 1997  
Title of Invention: OBJECT ORIENTED OPERATING SYSTEM  
Applicant(s) for DO/EO/US: Nicholas Simon Myers

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. (X) This is a **FIRST** submission of items concerning a filing under 35 USC 371.
2. ( ) This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371.
3. (X) This express request to begin national examination procedures (35 USC 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 USC 371(b) and PCT Articles 22 and 39(1).
4. (X) A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. (X) A copy of the International Application as filed (35 USC 371(c)(2))
  - a. ( ) is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. (X) has been transmitted by the International Bureau.
  - c. ( ) is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ( ) A translation of the International Application into English (35 USC 371(c)(2)).
7. (X) Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
  - a. ( ) are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ( ) have been transmitted by the International Bureau.
  - c. ( ) have not been made; however, the time limit for making such amendments has NOT expired.
  - d. (X) have not been made and will not be made.
8. ( ) A translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).
9. (X) An oath or declaration of the inventor(s) (35 USC 371(c)(4)).
10. ( ) A copy of the International Preliminary Examination Report with any annexes thereto, such as any amendments made under PCT Article 34.
11. ( ) A translation of the annexes, such as any amendments made under PCT Article 34, to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).
12. ( ) An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
13. (X) An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
14. (X) A **FIRST** preliminary amendment.

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- ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☒ A power of attorney and/or address letter.
17. ☒ International Application as published. (Cover page only)
18. ☐ Small Entity Statement.
19. ☐ PCT Form PCT/IPEA/402.
20. ☒ PCT Form PCT/IB/308.
21. ☐ PCT request form.
22. ☒ A copy of the International Search Report.
23. ☒ A return prepaid postcard.
24. ☒ The following fees are submitted:

				FEES
<b>BASIC FEE</b>				\$840
<b>CLAIMS</b>	<b>NUMBER FILED</b>	<b>NUMBER EXTRA</b>	<b>RATE</b>	
Total Claims	20 - 20 =	- 0 - ×	\$18	\$ - 0 -
Independent Claims	5 - 3 =	2 ×	\$78	\$156
Multiple dependent claims(s) (if applicable)			\$260	\$ - 0 -
<b>TOTAL OF ABOVE CALCULATIONS</b>				<b>\$996</b>
Reduction by 1/2 for filing by small entity (if applicable). Verified Small Entity statement must also be filed. (NOTE 37 CFR 1.9, 1.27, 1.28)				\$ - 0 -
<b>TOTAL NATIONAL FEE</b>				<b>\$996</b>
<b>TOTAL FEES ENCLOSED</b>				<b>\$996</b>
amount to be refunded:				\$ - 0 -
amount to be charged:				\$ - 0 -

25. ☒ A check in the amount of \$996 to cover the above fees is enclosed.
26. ☒ Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40 per property.

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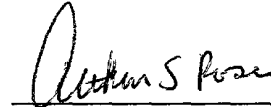
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27. (X) The Commissioner is hereby authorized to charge only those additional fees which may be required to avoid abandonment of the application, or credit any overpayment to Deposit Account No. 11-1410. A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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309 Rec'd PCT/PTO 12 FEB 1999

PATENT

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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Applicant	:	Nicholas Simon Myers	)	Group Art Unit Unknown
			)	
Appl. No.	:	Unknown	)	
			)	
Filed	:	Herewith	)	
			)	
For	:	OBJECT ORIENTED	)	
		OPERATING SYSTEM	)	
			)	
Examiner	:	Unknown	)	
			)	

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents

Washington, D.C. 20231

Dear Sir:

Prior to examination of the above-captioned application, please amend the application as follows:

**IN THE SPECIFICATION:**

On page 8, line 17, please insert --Brief Description of the Drawings

Figure 1 is an illustration of a constant pointer descriptor;

Figure 2A is an illustration of a modifiable pointer descriptor pointing to an area in memory;

Figure 2B is an illustration of a modifiable pointer descriptor pointing to another descriptor;

Figure 3 is an illustration of a constant buffer descriptor;

Figure 4 is an illustration of a modifiable pointer descriptor pointing to a constant buffer descriptor;

Figure 5 is an illustration of a modifiable buffer descriptor;

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Figure 6 is an illustration of a constant heap descriptor;

Figure 7 is an illustration of a modifiable pointer descriptor pointing to an allocated constant heap descriptor;

Figure 8 is an illustration of the member functions available to members of the various descriptor classes;

Figures 9, 10 illustrate an example to construct a pointer descriptor for leftmost part of data;

Figures 11, 12 illustrate an example to construct a pointer descriptor for rightmost part of data;

Figures 13, 14 illustrate an example to create a new heap descriptor;

Figures 15, 16 illustrate an example to copy from a descriptor and justify;

Figure 17 illustrates an example to append a descriptor and justify;

Figure 18 illustrates an example to append part of a descriptor and justify; and

Figure 19 illustrates an example to append a zero terminator.--

On page 8, line 24, please delete “, a section of which is attached as Appendix 1.”

On page 15, line 1, please delete “Detailed Description: Appendix 1.”

On page 91, line 8, please replace “Fugure 11” with --Figure 11--.

On page 89, line 15, please replace “Figure 10” with --Figure 10--.

On page 142, line 17, please replace “illustratedat” with --illustrated in--.

On page 166, line 1, please replace “Claims” with --WHAT IS CLAIMED IS:--.

#### IN THE CLAIMS:

Please cancel Claims 1-6 and 8-19 without prejudice.

Please add new Claims 20-38 as follows:

20. A computing device programmed with an object oriented operating system, in which the operating system is adapted to control objects related to text strings, wherein the operating system handles such objects as belonging to one of three classes, each class adapted to perform a different function and at least one such class modified to do so in a way that reduces code and cycle overhead.

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21. A peripheral device for a computer programmed with an object oriented operating system, wherein the operating system is adapted to handle objects related to text strings and to handle such objects as belonging to one of three classes, each class adapted to perform a different function and at least one such class modified to do so in a way that reduces code and cycle overhead, and wherein the peripheral device is programmed to handle objects which also fall into the above three classes.

22. An operating system for a computer, the operating system adapted to handle objects related to text strings and encoded on computer readable media, wherein the operating system handles the objects as belonging to one of three classes, each class optimized to perform a different function and at least one such class modified to do so in a way that reduces code and cycle overhead.

23. A method of operating a micro-processor using an operating system, comprising the steps of:

adapting the operating system to handle objects related to text strings;

handling the objects as belonging to one of three classes, each class performing a different function; and

modifying at least one class to reduce code and cycle overhead.

24. A computer readable media encoded with an operating system adapted to handle objects related to text strings and to handle the objects as belonging to one of three classes, each class adapted to perform a different function and at least one such class modified to do so in a way that reduces code and cycle overhead.

25. The operating system of Claim 22, wherein objects in one of the three classes are also pointers.

26. The operating system of Claim 25, wherein a pointer points to an original memory location of literal text.

27. The operating system of Claim 25, wherein the object is a flat structure.

28. The operating system of Claim 22, wherein objects in one of the three classes handle length limited text.

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29. The operating system of Claim 28, wherein those objects handling length limited text are serviced by a limited sub-set of potentially available memory management functions.

30. The operating system of Claim 29, wherein those objects handling length limited text use a static memory.

31. The operating system of Claim 28, wherein those objects handling length limited text are flat structures.

32. The operating system of Claim 22, wherein objects in one of the three classes use heap memory and require a full set of available memory management functions.

33. The operating system of Claim 22, wherein objects in any of the three classes are polymorphic.

34. The operating system of Claim 33, wherein polymorphism is achieved in one instance by virtue of the operating system comprising a function that looks to a predetermined field within each object and, depending on a value in that field, leads to a different kind of behavior.

35. The operating system of Claim 34, wherein the field shares a machine word with another data item.

36. The operating system of Claim 22, wherein the operating system is written in an 8-bit character set and a 16-bit character set invariant form by using aliases for class names that are an 8-bit character set and 16 bit character set invariant.

37. The operating system of Claim 36, wherein the operating system is written in code invariant form by using aliases for class names that are code invariant.

38. The operating system of Claim 22, wherein objects in any of the three classes are inherently length specified and hence have no '0' terminator.

#### REMARKS

The foregoing amendments are to more closely conform the application to U.S. practice.

Appl. No. : Unknown  
Filed : Herewith

No new matter is added. Entry of the amendments is respectfully requested.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR,

LLP

Dated: 2/12/99

By: Arthur S. Rose

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Object Oriented Operating System

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Field of the Invention

This invention relates to an improved object oriented operating system for a computer. In particular, it relates to an operating system which is based on C++ programming techniques. The commercially available embodiment of this operating system is the EPOC32 operating system produced by Psion Software Plc of England. EPOC32 is a preferred operating system in the mobile computing environment.

15 Description of the Prior Art

The C++ programming language is widely used for writing application programs for computers, such as Personal Computers, although it has only rarely been widely adopted for writing operating systems. When writing for Personal Computers, there is generally no overriding requirement to either minimise the size of the executable code or to minimise the number of cycles required for executing steps within the program. Typically, performance and ease of authorship are the more significant requirements.

But there are other contexts in which the executable code must occupy the minimum amount of space (e.g. to minimise the amount of ROM and/or RAM required to store it), and to execute in the minimum number of cycles (e.g. to minimise power consumption).

The mobile computing (e.g. personal digital assistants), smart phone (e.g. GSM cellular telephones with in-built word processing, facsimile send/receive and Internet browsing capabilities) and network computer ("NC") environments exemplify contexts in which there are advantages to minimising the code size of the operating system: namely, the hardware costs (particularly ROM and/or RAM) can then be reduced. That is particularly significant in the above contexts since widespread consumer adoption is generally

dependent on relatively low hardware pricing. Similarly, minimising processor execution cycles of the operating system is very important in the mobile computing and smart phone contexts, since doing so minimises power consumption and minimising power consumption is critical to long battery life. A fully architected operating system written in C++ would generally be substantial in size and be power hungry. Hence, it would be unsuitable for the mobile computing, smart phone and NC environments.

Further, it is generally regarded as difficult to design a fully functional operating system in C++ that meets stringent requirements for code size and cycle overhead, particularly the stringent requirements associated with the mobile, smart phone and NC computing environments.

### Some Terminology

#### “Objects of the String Class”

In C++, text (e.g. strings of letters that will actually appear on a computer screen) is represented as an “Object”. The implementer skilled in C++ or other object oriented languages will be familiar with this categorisation. Such text related Objects are of a particular type, which we shall call “Objects of the String Class”: The kind of Class that an Object belongs to (e.g. in the case of text, the String Class) defines the allowable manipulations that can be performed on that Object. Only certain manipulations can be performed on Objects of the String Class (e.g. concatenating 2 text strings together). A particular Object of the String Class therefore represents a particular text string. It can only be manipulated in certain, well defined ways.

The following steps are performed in conventional C++ programming in order to create an Object of the String Class from an item of text, where the text resides in a file in the filing system:

- set aside a buffer location in memory

- read the text into the buffer using a file reading service
- use a string creation service to turn the buffered data into an Object of the String Class
- discard the buffer contents

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The actual storage location of the text string is difficult to identify in C++, but one does not need to know its location since it is the Object of the String Class that one manipulates directly: that in turn causes the actual text string to be manipulated. Hence the Object of the String Class in effect knows the memory location of the text string and can handle all the

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necessary memory management tasks associated with text manipulation.

### Multiple Classes of Objects of the String Class

In the version of C++ known as the draft ANSI/ISO C++ Standard, all Objects of the String Class (as exemplified by the string class in that part of the draft C++ Standard Library of the above Standard referred to as `<string>`) are handled in a manner that enables sophisticated memory management tasks to be accomplished (e.g. re-allocating buffer space for text that can grow or shrink or be spliced - fully dynamic text). But this level of memory management uses a great deal of code and may require considerable heap space.

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Two examples of conventional C++ memory management illustrate this:

### Example 1: C++ handling of Literal Text

In C++, there are many instances in which source code contains text strings. These strings are known as 'Literal Text' and are permanently stored in buffer memory on compilation of the source code into executable object code. When Literal Text is to be manipulated, then an Object of the String Class must be created from it. However, creation of that Object of the String Class itself leads to the creation in memory of the text string which the newly created Object of the String Class in fact manipulates. Hence, the text string is duplicated in memory: once in the original buffer that arises on compilation of the source code and again

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in the memory location associated with the Object of the String Class that enables the text to be manipulated.

As noted above, in some computing environments, code space and power consumption are at a premium. However, in conventional C++ (i.e. as implemented in the draft ANSI/ISO C++ Standard), there is no mechanism to overcome the inherent duplication in memory of Literal Text. That is problematic, especially for an operating system since, in an operating system, there are many occasions in which Literal Text must be handled.

#### 10 Example 2: C++ handling of length limited text

In C++, a programmer handles text using heap memory. Text whose length is limited does not in fact require the fully flexible approach that is needed to handle text whose length is not limited. However, in conventional C++, there is no mechanism for using anything other than fully flexible, fully featured Objects of the String Class, irrespective of the length of text. That leads to a high overhead in memory management code since handling heap memory is code and cycle intensive.

Overall, text memory management in C++ is code and cycle intensive. Since code space and power consumption are at a premium in mobile environments, the conventional C++ approach would lead to an operating system that is unacceptably large in terms of code size and is also too power hungry.

#### Statement of the Invention

The operating system of the present invention re-defines Objects of the String Class (i.e. as defined in the draft ANSI/ISO C++ Standard), by substituting them with a three fold structure of Objects of the String Class, namely three new Classes of Objects. The conventional, fully featured memory management functionality associated with <string> from the draft ANSI/ISO C++ Standard is not applied to all three of the new classes. Whilst

that full functionality is useful in many environments, it is problematic in (inter alia) mobile computing environments in which code space and power consumption are at a premium.

- 5 Hence, the generalisation of the inventive concept of the present invention is to minimise code size and cycle overhead by providing, in a computer operating system, a family of three different Classes for handling text strings: each different class is appropriate for a different circumstance. This allows flexibility: for example, the fully featured memory management functionality can now be applied solely to those text strings that actually
- 10 require it.

We shall refer to this new family of String Class Objects as "Descriptors". In a preferred embodiment, we call the members of this family "Pointer Descriptors", "Buffer Descriptors" and "Heap Descriptors". Care should be taken to note that these concepts are

15 different (although related to) the established concepts of "pointers", "buffers" and "heaps", with which the skilled implementer will be familiar. Care should also be taken to note that the Descriptors envisaged in this specification have no relationship to the VMS facility of the same name, nor the UNIX term for small integer numbers used to identify active operating system files. The skilled implementer may appreciate that it is possible to

20 design an operating system in which the number of Classes for handling text strings exceeds three: such variants are within the scope of the present invention. The three fold structure is the minimum (and in almost all cases, the most effective) proliferation of Classes.

- 25 Further, Descriptors are preferably polymorphic: hence, a single service can operate on all Descriptors. That leads to significant savings in code and, to a lesser extent, cycle overhead, since otherwise modified services would be needed for each of different Descriptors.

Hence, in accordance with a first aspect of the present invention, there is provided a computer programmed with an object oriented operating system, in which the operating system is adapted to handle objects related to text strings;

characterised in that the operating system handles all such objects as belonging to one of three classes (namely the Pointer Descriptor Class, the Buffer Descriptor Class and the Heap Descriptor Class), in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.

The invention is founded upon the insight that in order to deliver significant reductions in code and cycle overhead, one has to re-design the operating system by substituting the conventional, single form of Object of the String Class (for example) with three different forms of that Object: each form is optimised for different circumstances.

In a preferred form of the invention, conventional, memory intensive text handling techniques are applied only to Objects which fall within the new Descriptor Class which defines Objects requiring such techniques (i.e. Heap Descriptors). The Pointer and Buffer Descriptor Classes are however designed in a manner that reduces code and processor cycles compared to conventional String Classes.

Using the two examples mentioned in the Description of the Prior Art above (i.e. Example 1: C++ handling of literal text and Example 2: C++ handling of length limited text), the operating system of the present invention (i) handles Literal Text in a manner that eliminates the need for a duplicate copy of Literal Text and (ii) handles text which is determined dynamically at run time in a manner that only requires code intensive utilisation of heap memory in those limited circumstances in which it is actually necessary to do so: in other circumstances (for example, where the programmer knows in advance the maximum length of the text), then static memory is used instead. Fuller details of the specific handling is given below (see section titled Detailed Description).

Preferably, the operating system is adapted to handle not only text but also raw data using the same three fold structure.

In addition to the combined computer/operating system as defined above, one can identify further inventive aspects. For example, any device that has to interface with such an operating system must also use the same three-fold structure for Objects of the String Class. For example, driver software for peripherals such as solid state memory devices will have to use this three fold-structure. Likewise, control panel software for peripherals will also have to.

Hence, in a second aspect of the present invention, there is provided a peripheral device for a computer programmed with an object oriented operating system, in which the operating system is adapted to handle objects related to text strings;

characterised in that the operating system handles all such objects as belonging to one of three classes (namely the Pointer Descriptor Class, the Buffer Descriptor Class and the Heap Descriptor Class), in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead and is further characterised in that the peripheral device is programmed to handle objects which also fall into the above three classes.

In a third aspect of the present invention, there is provided an operating system encoded on computer readable media, in which the operating system handles objects related to text strings;

characterised in that the operating system is adapted to handle all such objects as belonging to one of three classes (namely the Pointer Descriptor Class, the Buffer Descriptor Class and the Heap Descriptor Class), in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.

In a fourth aspect of the invention, there is provided a method of operating a micro-processor using an operating system, in which the operating system is adapted to handle objects related to text strings;

characterised in that the operating system handles all such objects as belonging to one of three classes (namely the Pointer Descriptor Class, the Buffer Descriptor Class and the Heap Descriptor Class), in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.

In a fifth aspect, there is provided computer readable media encoded with an operating system adapted to handle objects related to text strings;

characterised in that the operating system handles all such objects as belonging to one of three classes, in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead. Typically, the computer readable media will be a masked ROM. For distribution purposes, the media may also be a conventional CD-ROM or floppy disc.

### Detailed Description

The present invention will be described in relation to an embodiment known as EPOC32. EPOC32 is a 32 bit operating system developed by Psion Software plc of England for use in (inter alia) mobile and smart phone environments. Further details of the EPOC32 embodiment are disclosed in the SDK on EPOC32 published by Psion Software Plc, England, a section of which is attached as Appendix 1. To the extent possible without limiting in any way the rights of the inventors and assignees of this invention, the full SDK is incorporated by reference into this specification.

EPOC32 has been ported to run on a number of different micro-processor architectures. The details of porting an operating system per se are beyond the scope of this specification, but will be understood by those skilled in the arts. In particular, EPOC32 has been ported to



run on ARM RISC-based micro-processors from Advanced RISC Machines of England. Various models of ARM micro-processors are widely used in digital cellular telephones and will be familiar to those skilled in the art. However, the invention can be realised on many different micro-processors. Hence, the claims of this specification should be read to

5 cover any and every hardware and software implementation in which the operating system performs the functions as limited in the claims.

Returning to the examples of Literal Text and Length Limited Text given in the Prior Art discussion above, EPOC32 applies the above three-fold structure for Objects of the String

10 Class as follows:

#### Example 1: Literal Text in EPOC32

As explained above, in conventional C++, a text string relating to Literal Text is duplicated in memory: once in the original buffer that arises on compilation of the source code and

15 again in the memory location associated with the Object of the String Class that enables the text to be manipulated. That duplication is wasteful.

EPOC32 however uses a Pointer Descriptor which points to the original memory location of the Literal Text (i.e. as laid down by the compiler). This Pointer Descriptor (called the

20 TPTrC Pointer Descriptor in EPOC32) is the Object of the String Class for Literal Text. (In C++, pointers are not usually regarded as Objects per se). Hence, the hybrid pointer/object in EPOC32 leads to the complete elimination of the need for an additional copy of Literal Text.

#### 25 Example 2: Length Limited Text in EPOC32

As noted above, in conventional C++, there is no mechanism for using anything other than fully flexible, fully featured Objects of the String Class, irrespective of the length of text. That leads to a high overhead in memory management code since handling heap memory is code and cycle intensive.

In EPOC32, there is a particular class of String Objects, known as Buffer Descriptors, which are size limited. Because they are size limited, complex memory allocation code is not required to manipulate them. Further, Buffer Descriptors can use Static Memory (rather than heap memory). Static memory cannot be re-allocated in the code intensive fashion that heap memory can be, but is more efficient to use in that fewer code cycles are required to achieve the necessary manipulations (hence leading to power saving). Only in the truly dynamic case does EPOC32 require use of the heap memory with its attendant high cycle overhead: Then, the Heap Descriptor Class is used.

EPOC32 lays down the parameters of length limited String Classes using a template class, the 'TBuf' class. (Class templates define the properties of numerous Objects of the String Class; e.g. TBuf is the template for all Buffer Descriptors - i.e. all Objects of the String Class of the Buffer variant. TBuf defines certain common properties for all such Objects of the String Class.)

EPOC32 exhibits several other significant features which lead to minimising code size and cycle overhead, namely that:

- String and Raw Data Buffer Class Objects act as 'flat' structures
- Descriptors give polymorphic characteristics
- Descriptors allow for UNICODE and ASCII invariant coding

### String and Raw Data Buffer Class Objects as flat structures

All Descriptors are 'flat' structures (i.e. if a Descriptor has to be copied, then only the Descriptor itself is copied. In conventional C++, copying an Object requires copying not only of the Object itself, but also all related pointers and the data pointed to - i.e. the complex, related structure that gives an Object meaning.) In EPOC32, copying a Descriptor is therefore far more economic in memory overhead and cycles than copying an equivalent Object in ordinary C++.

This is achieved in EPOC32 as follows, for Buffers and Pointers:

Buffer Descriptors (TBuf) contain the actual text referenced by the Buffer: hence, copying the Buffer inherently copies the related text. There is no need to copy a pointer and related data as there would be in C++.

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Pointer Descriptors (TPtr) contain a C++ type pointer within them, so that copying TPtr alone is all that is required when duplicating: in conventional C++, one would have had to copy not just one entity, but also related and separate pointers and text.

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### Descriptors as Polymorphic Objects

A group of Objects are said to exhibit polymorphism if all the Objects in the Group behave like a single Object, yet achieve common behaviour through different mechanisms.

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Polymorphism is provided for in conventional C++ through Virtual Functions: all Objects which are polymorphic to one another include, at a common location, a pointer to a Virtual Function Table (a pointer is therefore required in each Object). This Table identifies the actual code for each polymorphic function. A separate Table is needed for each class that shares polymorphism. But this approach uses a considerable amount of space, since each pointer is 32 bits (i.e. 4 characters) and each Object needs a pointer to a Virtual Function Table. In addition, a 32 bit length field is also used in each Object.

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In (inter alia) mobile operating system environments, this overhead is problematic. EPOC32 addresses this as follows for Objects of the String Class: a 32 bit length field is sub-divided so that the first 4 bits code for the type of Descriptor. A function then looks at the 4 bits and points to the correct text location (e.g. within the Descriptor itself if the Descriptor is a Buffer etc.) Hence, polymorphism is provided for in that each of the three different classes of Descriptors for Objects of the String Class (i.e. Pointer Descriptors, Buffer Descriptors and Heap Descriptors) can be coded for using merely the first 4 bits of a

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single 32 bit field. Hence, considerable memory savings can be achieved. In more general terms, the field shares a machine word with another data item.

### UNICODE and ASCII Invariant Code

- 5 In C++, coding for 16 bit Unicode leads to doubling in size of all text data that would otherwise be in 8 bit code. Also, conventionally, a programmer has to decide when writing source code whether to code for text using ASCII or Unicode.

- 10 In EPOC32, the same source code is used irrespective of the ultimate choice of ASCII or Unicode. This is achieved by building the system using aliases for Class Names, which are ASCII and Unicode invariant, rather than Classes per se (e.g. Pointer Descriptors, Buffer Descriptors and Heap Descriptors). Hence, instead of building using the Pointer TPtr16 to code for Unicode or TPtr8 to code for ASCII, one instead builds using the TPtr Class Name. At build time, the Class Names can be compiled as either 16bit Unicode or 8bit  
15 ASCII. This approach can be used to encompass all character sets which can be encoded in different bit lengths.

### Additional Advantages of EPOC32

- 20 In C++, text strings are conventionally terminated with a '0' so that the system can readily know where a text string ends. In EPOC32, that is no longer necessary; Descriptors include a statement defining the length of the data referenced. Hence, there is a yet further saving in code since it no longer needs to use '0' terminators to flag the end of each and every text  
25 item.

### Summary of Descriptors Features

- Descriptors come in 3 classes: **Pointer Descriptors, Buffer Descriptors and Heap Descriptors.**
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- **Pointer Descriptors** come in two forms: constant Pointer Descriptors: TPtrC and modifiable Pointer Descriptors: TPtr
  - constant Pointer Descriptors: TPtrC.
    - Data cannot be modified through this.
    - All member functions are constant.
    - Is used to reference constant strings or data (e.g. data that must not be altered).
    - Is derived from TDesC and hence has a large number of member functions.
  - modifiable Pointer Descriptors: TPtr.
    - Data can be modified through this Descriptor, so long as the data does not extend beyond the maximum length set by the constructor.
    - Points directly to a memory area containing the area to be modified.
    - Pointer length determines number of data items that are contained.
    - Inherits all the TDesC member functions, plus TDes member functions for manipulating and changing data.
  - Pointer Descriptors are separate from the data represented; but are constructed from a pre-existing area in memory.
- **Buffer Descriptors** come in two forms
  - constant Buffer Descriptor, TBufC<TInt S>
    - data can be set into the Descriptor at construction time or by the assignment operator (operator =) later on.
    - length is defined by an integer template: TBufC<40> contains 40 data items.
    - Inherits all the TDesC member functions
  - a modifiable Buffer Descriptor, TBuf<TInt S>

- contains data that can be modified, so long as the data is not modified to extend beyond the maximum length.
- maximum length defines the max. number of data items
- actual length defines actual number of data items
- 5      • length is defined by an integer template: TBuf<40> contains 40 data items and no more.
- the data area is part of the Descriptor object
- useful for containing data which needs to be manipulated and changed , but whose length will not exceed a known maximum (e.g. WP text).
- 10      • Inherits all the TDesC member functions, plus TDes member functions for manipulating and changing data.
- **Heap Descriptors** come in one form only
- 15      • constant Heap Descriptor HBufC
- contains a length followed by data
- the data area is part of the Descriptor object; the whole object occupies a cell allocated from the heap.
- Data can be set into the Descriptor at construction time or by the assignment operator (operator =) later on.
- 20      • Inherits all the TDesC member functions
- can be re-allocated: data area can expand or contract

## Detailed Description: Appendix 1

- 5 EPOC32 “Descriptors” SDK 1997 from Psion Software Plc. (excerpts). Reference to the full SDK, published in July 1997 (rev. 1.0) by Psion Software plc, may be made.

---

10 **SDK: Descriptors Overview**

15 The three fold structure of the Descriptor Classes (namely the Pointer Descriptor Class, the Buffer Descriptor Class and the Heap Descriptor Class), offer a safe and consistent mechanism for accessing and manipulating both strings and general binary data regardless of the type of memory that they live in. For example, a string within a code segment in ROM can be handled in a similar way to a file record in RAM.

20 The data represented by Descriptors resides in a data area which is a defined location in memory. This data area is *not expandable*. Operations on Descriptor data are safe in the sense that accidental or deliberate attempts to access memory outside the defined data area, are not permitted.. (In general, code which makes an invalid access, causes an exception (commonly known as a panic).

25 Descriptors make no distinction between the type of data represented; both strings and binary data are treated in the same way. Although some member functions of a Descriptor object are designed to operate on text data, they will, nevertheless, work on binary data. This unifies the handling of both text and binary data and increases efficiency by allowing code to be shared.

Descriptor Classes satisfy a number of important requirements:

- They provide support for both UNICODE and ASCII text. The `_UNICODE` macro is used to select the ASCII or UNICODE build variant.
- They unify the handling of both strings and binary data.
- They allow text or data in ROM to be safely and conveniently referenced.
- 5 • They supply rich member functions to manipulate the associated text or data.
- They allow the data to be modified but prevent any attempt to write outside the defined data area.
- They avoid the memory overhead associated with virtual functions.
- They behave as built-in types and can be safely created on the stack and can
- 10 also be safely *orphaned*.
- (HBufC is allocated on the heap and is an exception to the rule).

---

## ASCII and UNICODE text

### E32.descriptors.char-set

- 15 ASCII text characters can be represented by 8 bits (one byte) while UNICODE characters require 16 bits (two bytes). To support both ASCII and UNICODE text, the Descriptor Classes come in two variants: 8 bit and 16 bit. For example, there are the following two Pointer Descriptor Classes: TPTr8 and TPTr16.
- 20 Programs can be built to support either UNICODE or ASCII text by using class names which are independent of the build variant. For example, by using the Descriptor class TPTr, a system can be built that will use either the TPTr8 or TPTr16 classes. The decision is taken at build time and depends on whether the `_UNICODE` macro has been defined.



The following code fragments extracted from the E3232def.h header file (see Appendix 1 for the SDK) show how this is implemented by defining the variant independent class names as appropriate.

```

5      #if defined(_UNICODE)
      ...
      typedef TPtr16 TPtr;
      ...
      #else
10     ...
      typedef TPtr8 TPtr;
      ...
      #endif

```

Application code should avoid using ‘C’ style string literals directly. Instead, one should use the `_S` macro to create a ‘C’ style string of the appropriate width, returning a pointer of the appropriate type. Also, one should use the `_L` macro (`_L` for “literal”) to create a Descriptor of the appropriate type. See `e32.macro._S` and `e32.macro._L` for the definitions of these macros.

For example,

```

20     const TText* str = _S("Hello");

```

generates a string of single byte characters in an ASCII build but a string of double-byte characters in a UNICODE build.

```

    _L("Hello");

```

generates an 8 bit Descriptor in an ASCII build and a 16 bit Descriptor in a UNICODE build. Always use `_L("abcdef")` , for example, rather than plain `"abcdef"` as it will always construct a Descriptor of the correct variant.

Note that an 8 bit ‘C’ style string and an 8 bit pointer Descriptor can be explicitly constructed, independently of the build variant, by using the `_S8` and `_L8` macros respectively. The corresponding 16 bit versions, `_S16` and `_L16` are also available.

See `e32.macro. S8`, `e32.macro. L8`, `e32.macro. S16` and `e32.macro. L16` for their definitions.

---

## Length and size

### E3232.descriptors.length-and-size

- 5 A Descriptor characterizes the data it represents by the length of that data. The *length* of a Descriptor is the number of data items. For the 8 bit variants, the length of the Descriptor is the number of single-bytes of data it represents; for the 16 bit variants, the length of the Descriptor is the number of double-bytes of data it represents.
- 10 The *size* of a Descriptor is the number of bytes occupied by the Descriptor's data; this is not necessarily the same as the Descriptor's length. For the 8 bit variants, the size *is* the same as the length but for the 16 bit variants, the size is *twice* the length. Those Descriptors which allow their data to be modified are also characterized by their maximum length. For these Descriptors, the length of data represented can vary from zero up to and including this
- 15 maximum value. The maximum length for any Descriptor is  $2^{28}$ .

---

## Text and binary data

### E3232.descriptors.text-and-binary

- In 'C', strings are characterized by the need for a zero terminator to flag the end of the string. They suffer from a number of problems. In particular, they cannot include binary
- 20 data within them (in case that data includes binary zeroes) and operations on them are, in general, inefficient. 'C' strings need to be handled in a different way to binary data, as reflected in the `memxxx()` and `strxxx()` function groups in the ANSI 'C' library. Descriptors allow strings and binary data to be represented in the same way; this allows the same functions to be used in both cases. For binary data, the 8 bit Descriptors should be
- 25 used explicitly. The distinction between UNICODE and ASCII has no meaning for binary data. Note that there is no practical use for explicit 16 bit binary data.

---

## Memory allocation

### E3232.descriptors.alloc

The Descriptor classes (except HBufC) behave as built-in types. They allocate no memory and have no destructors. This means that they can be *orphaned* on the stack in the same way as a built-in type. This is particularly important in situations where code can leave. (See [E3232.exception.trap.cleanup.requirements](#) for the implications of *orphaning*).

- 5 An HBufC Descriptor object is allocated on the heap and cannot be created on the stack.

---

## Exceptions

### [E3232.descriptors.exceptions](#)

- All parameters to Descriptor member functions are checked to ensure that the operations are correctly specified and that no data is written outside the Descriptor's data area. A particular consequence is that no member function can extend a modifiable Descriptor beyond its maximum allocated length. It is the programmer's responsibility to ensure that all Descriptors are sufficiently large to contain their data, either by making the original allocation large enough or by anticipating the need for a larger Descriptor and dynamically allocating one at run-time. The static approach is simpler to implement but if this were to prove wasteful in a specific case, then the dynamic approach could be more worthwhile. In the event of an exception, it can be safely assumed that no illegal access of memory has taken place and that no data has been moved or damaged.

---

## The Descriptor types

### [E3232.descriptors.types](#)

- 20 There are three kinds of Descriptor object:

- *pointer* Descriptors.

The Descriptor object is separate from the data it represents but is constructed for a pre-existing area in memory. They come in two forms:

- a constant pointer Descriptor, TPtrC
- 25 a modifiable pointer Descriptor, TPtr

- *buffer* Descriptors.

The data area is part of the Descriptor object. They come in two forms:

- a constant buffer Descriptor, TBufC<TInt S>

a modifiable buffer Descriptor, TBuf<TInt S>

- *heap* Descriptor.

The data area is part of the Descriptor object and the whole object occupies a cell allocated from the heap. This comes in only one form:

5 a constant heap Descriptor, HBufC

---

### Pointer Descriptor - TPtrC

E3232.descriptors.buffer-descriptor.TPtrC

TPtrC is a constant Descriptor through which no data can be modified. All of its member  
 10 functions (except the constructors) are constant. TPtrC is shown schematically at Figure 1.  
 TPtrC is useful for referencing constant strings or data; for example, accessing text built  
 into ROM resident code, or passing a reference to data in RAM which must not be  
 modified through that reference. TPtrC is derived from TDesC, which provides a large  
 number of member functions for operating on its content; for example, locating characters  
 15 within text or extracting portions of data.

---

### Pointer Descriptor - TPtr

E3232.descriptors.buffer-descriptor.TPtr

TPtr is a modifiable pointer Descriptor through which data can be modified, *provided that*  
 20 *the data is not extended beyond the maximum length.* The maximum length is set by the  
 constructor. TPtr points directly to an area in memory containing the data to be modified.  
 TPtr is shown schematically in Figures 2A and 2B.

The maximum number of data items that the area can contain is defined by the maximum  
 25 length. The length of the TPtr indicates how many data items are currently contained within  
 the data. When this value is less than the maximum, a portion of the data area is unused.  
 TPtr is useful for constructing a reference to an area of RAM which contains data intended  
 to be modified through that reference, or even to an area of RAM which contains no data

yet but in which data will be constructed using the Descriptor reference and member functions.

TPtr is also useful for constructing a reference to a TBufC or an HBufC Descriptor which contain the data to be modified. A TPtr used in this way points to a TBufC or an HBufC Descriptor. The data contained by the TBufC or HBufC Descriptors can be modified through the TPtr. TPtr is derived from TDes which, in turn, is derived from TDesC. Therefore, it inherits all the const member functions defined in TDesC plus the member functions from TDes which can manipulate and *change* the data; for example, appending a character to the end of existing text.

---

### Buffer Descriptor - TBufC<TInt S>

E3232.descriptors.buffer-descriptor.TBufC

TBufC is a buffer Descriptor containing a length followed by the data area. Data can be set into the Descriptor at construction time or by the assignment operator (operator=) at any other time. Data already held by the Descriptor is constant. TBufC is shown schematically at Figure 3. The length of a TBufC is defined by an integer template; for example, TBufC<40> defines a TBufC which can contain up to 40 data items.

TBufC is derived from TDesC, which provides a large number of member functions for operating on its content; for example, locating characters within text or extracting portions of data. TBufC provides the member function, Des(), which creates a modifiable *pointer* Descriptor (a TPtr) to reference the TBufC. This allows the TBufC data to be changed through the TPtr, as indicated schematically at Figure 4. The maximum length of the TPtr is the value of the integer template parameter.

---

### Buffer Descriptor - TBuf<TInt S>

E3232.descriptors.buffer-descriptor.TBuf

TBuf is a modifiable buffer Descriptor containing data which can be modified, *provided that the data is not extended beyond its maximum length*.. TBuf is shown schematically at Figure 5. The maximum number of data items that the data area within TBuf can contain, is defined by the maximum length. The length of the Descriptor indicates how many data items are currently contained within the data area. When this value is less than the maximum, a portion of the data area is unused. The *maximum length* of a TBuf is defined by an integer template; for example, TBuf<40> defines a TBuf which can contain up to 40 data items (and no more!). A TBuf is useful for containing data which needs to be manipulated and changed but whose length will not exceed a known maximum; for example, word processor text. TBuf is derived from TDes which, in turn, is derived from TDesC. Therefore, it inherits all the const member functions defined in TDesC plus the member functions from TDes which can manipulate and *change* the data; for example, appending a character to the end of existing text.

---

### Heap Descriptor - HBufC

E3232.descriptors.buffer-descriptor.HBufC

HBufC is a Descriptor containing a length followed by data. It is allocated on the heap using the New(), NewL() or NewLC() static member functions. The length of the Descriptor is passed as a parameter to these static functions. HBufC is shown schematically at Figure 6. Data can be set into the Descriptor at construction time or by the assignment operator (operator=) at *any* other time. Data already contained by the Descriptor is constant. HBufC is derived from TDesC, which provides a large number of member functions for operating on its content; for example, locating characters within text or extracting portions of data.

HBufC provides the member function, Des(), which creates a modifiable *pointer* Descriptor (a TPtr) to reference the HBufC. This allows the HBufC data to be changed through the TPtr. The maximum length of the TPtr is the length of the HBufC data area. Figure 7 illustrates this schematically.

Heap Descriptors can be re-allocated. The ReAlloc() or ReAllocL() functions allow the heap Descriptor's data area to expand or contract. The length of the data area, however, cannot be made smaller than the length of data currently held. Before contracting the data area, the length of the data held by the Descriptor must be reduced. The length of data which the assignment operator can set into the heap Descriptor is limited by the space allocated to the Descriptor's data area. The memory occupied by heap Descriptors must be explicitly freed either by calling User::Free() or by using the delete keyword.

## The Descriptor classes' relationships

### E32.descriptors.classes

All of the Descriptor classes TPtrC, TPtr, TBufC, TBuf and HBufC are derived from the abstract base classes TDesC and TDes. The class TBufCBase, although marked as an abstract class, is merely an implementation convenience. Figure 8 schematically illustrates the relationship between the classes.

The behaviour of the concrete Descriptor classes is very similar, and therefore, most of the functionality of Descriptors is provided by the abstract base classes. Because Descriptors are widely used (especially on the stack), the size of Descriptor objects must be kept to a minimum. To help with this, no virtual functions are defined in order to avoid the overhead of a virtual function table pointer in each Descriptor object. As a consequence, the base classes have implicit knowledge of the classes derived from them. E32 supplies two variants of the Descriptor classes, one for handling 8 bit (ASCII) text and binary data and the other for handling 16 bit (UNICODE) text. The 8 bit variants of the concrete classes are: TPtrC8, TPtr8, TBufC8<TInt S>, TBuf8<TInt S> and HBufC8 while the 8 bit variants of the abstract classes are:- TDesC8, TDes8. Similarly, the 16 bit variants are named: TPtrC16, TPtr16, TBufC16<TInt S>, TBuf16<TInt S>, HBufC16, TDesC16 and TDes16 respectively. This distinction is transparent for Descriptors intended to represent text. By

writing programs which construct and use TPtrC, TPtr, TBufC<TInt S>, TBuf<TInt S> and HBufC classes, compatibility is maintained between both UNICODE and ASCII. The appropriate variant is selected at build time depending on whether the \_UNICODE macro has been defined or not. If the \_UNICODE macro is defined, the 16 bit variant is used,  
 5 otherwise the 8 bit variant is used as explained in [e32.descriptors.char-set](#)

Descriptors for binary data must *explicitly* use the 8 bit variants; in other words, code must explicitly construct TPtrC8, TPtr8, TBufC8<TInt S>, TBuf8<TInt S> and HBufC8 classes. Explicit use of the 16 bit variants for binary data is possible but not recommended. In  
 10 general, 8 bit and 16 bit variants are identical in structure and implementation; the description of the classes themselves uses the build independent names throughout.

N.B. Many member functions take arguments which are either of type TUint8\* or type TUint16\* depending on whether the Descriptor is the 8 bit or 16 bit variant. To simplify  
 15 explanation, these arguments are written in function prototypes as TUint??\*.

---

## Using descriptors for function interfaces

### [e32.descriptors.using-function-interfaces](#)

Many interfaces which use or manipulate text strings or general binary data use descriptors to specify the interface. In conventional 'C' programming, interfaces would be specified  
 20 using a combination of char\*, void\* and length values. In E32 descriptors are always used.

There are four main cases:

- Passing a constant string

In 'C': StringRead(const char\* aString);

The length of the string is implied by the zero terminator; therefore, the  
 25 function does not require the length to be explicitly specified.

In E32: StringRead(const TDesC& aString);

The descriptor contains both the string and its length.

- Passing a string which can be changed.

In 'C': StringWrite(char\* aString, int aMaxLength);



The length of the passed string is implied by the zero terminator. aMaxLength indicates the maximum length to which the string may be extended.

In E32: StringWrite(TDes& aString);

The descriptor contains the string, its length and the maximum length to which the string may be extended.

- Passing a buffer containing general binary data

In 'C': BufferRead(const void\* aBuffer, int aLength);

Both the address and length of the buffer must be specified.

In E32: BufferRead(const TDes8& aBuffer);

The descriptor contains both the address and the length of the data. The 8 bit variant is explicitly specified; the buffer is treated as byte data, regardless of the build variant.

- Passing a buffer containing general binary data which can be changed.

In 'C':

BufferWrite(void\* aBuffer, int& aLength, int aMaxLength);

The address of the buffer, the current length of the data and the maximum length of the buffer are specified. The aLength parameter is specified as a reference to allow the function to indicate the length of the data on return.

In E32: BufferRead(TDes8& aBuffer);

The descriptor contains the address, the length of the data and the maximum length. The 8 bit variant is explicitly specified; the buffer is treated as byte data, regardless of the build variant.

---

## Folding and collating

[e32.descriptors.folding-collating](#)

There are two techniques that may be used to modify the characters in a descriptor prior to performing some operations on text:

- folding
- collating

Variants of member functions that fold or collate are provided where appropriate.

---

## Folding

[e32.descriptors.folding](#)

Folding means the removal of differences between characters that are deemed unimportant for the purposes of inexact or case-insensitive matching. As well as ignoring differences of case, folding ignores any accent on a character. By convention, folding converts lower case characters into upper case and removes any accent.

---

## Collating

[e32.descriptors.collating](#)

Collating means the removal of differences between characters that are deemed unimportant for the purposes of ordering characters into their collating sequence. For example, collate two strings if they are to be arranged in properly sorted order; this may be different from a strict alphabetic order.

---

## Using descriptors

[e32.descriptors.using](#)

The following series of examples show how descriptors can be used. Specifically, the examples illustrate:

- the basic concepts of the pointer descriptors, TPtrC and TPtr. See [e32.descriptors.using.pointer-descriptors](#).
- the basic concepts of the buffer descriptors, TBufC and TBuf. See [e32.descriptors.using.buffer-descriptors](#).
- how descriptors can represent general binary data. See [e32.descriptors.using.general-binary-data](#).
- some of the member functions which do not modify the content of a descriptor. See [e32.descriptors.using.non-modifying-functions](#).
- some of the member functions which modify the content of a descriptor. See [e32.descriptors.using.modifying-functions](#).
- how descriptors can be used in interfaces. See [e32.descriptors.using.interface-specifiers](#).

- the basic concepts of the heap descriptor, HBufC. See [e32.descriptors.using.heap-descriptors](#).

---

## Pointer descriptors

[e32.descriptors.using.pointer-descriptors](#)

- 5 The code fragments shown here to illustrate the use of pointer descriptors are extracted from the sample source code in the **eudesptr** project. Run the code in this project to see pointer descriptors in action.

---

### TPtrC

#### The 8 bit variant

- 10 A TPtrC is useful for referencing constant strings or data; for example, accessing text built into ROM resident code, or passing a reference to data in RAM which must not be modified through that reference.

For example, define a constant 'C' style ASCII string:

```
const TText8* cstr8 = (TText8*)"Hello World!";
```

- 15 A TPtrC8 descriptor can be constructed to represent this pre-defined area containing the string "Hello World!":

```
TPtrC8 ptrC8(cstr8);
```

The descriptor is separate from the data it represents.

While the length of the 'C' string is 12, its size is 13 to allow for the zero terminator. From

- 20 the descriptor's viewpoint, both the length and the size of the data is 12. The descriptor uses the length to determine the amount of data represented. The address of the descriptor's data area, as returned by:

```
ptrC8.Ptr();
```

is the same as same as the address of the original 'C' string, cstr8.

#### 25 The 16 bit variant (UNICODE)

Similarly, define a constant 'C' style string of wide (or UNICODE) characters:

```
const TText16* cstr16 = (TText16*)L"Hello World!";
```

A TPtrC16 descriptor can be constructed to represent this area containing the string of double-byte characters "Hello World!":

```
TPtrC16 ptrC16(cstr16);
```

Again, the descriptor is separate from the data it represents. The length of the descriptor, as returned by a call to `ptrc16.Length()`, is 12 as it represents 12 text characters but the size, as returned by a call to `ptrc16.Size()`, is now 24 as each character occupies 2 bytes.

- 5 Again, the address of the descriptor's data area, as returned by:

```
ptrc16.Ptr();
```

is the same as the address of the original 'C' string, `cstr16`.

### The `_S` macro and build independent names

Use the `_S` macro to define a constant 'C' style string of the appropriate width. The `TText` variant is defined at build time (as either `TText8` or `TText16`) depending on whether the `_UNICODE` macro has been defined. For example:

```
const TText* cstr = _S("Hello World!");
```

The `TPtrC` descriptor:

```
TPtrC ptrc(cstr);
```

- 15 represents the area containing the text "Hello World!"; the `TPtrC` variant is defined at build time (as either `TPtrC8` or `TPtrC16`) depending on whether the `_UNICODE` macro has been defined.

The length of the descriptor, as returned by `ptrc.Length()`, is 12 for all build variants but the size of the descriptor, as returned by `ptrc.Size()` is 12 for an ASCII build and 24 for a

- 20 UNICODE build.

See [e32.macro.S](#).

### The `_L` macro

The `_L` macro constructs a `TPtrC` of the correct variant and is frequently used as a source descriptor when constructing a buffer descriptor or a heap descriptor.

- 25 The macro is also useful for constructing a `TPtrC` to be passed as a parameter to a function. For example, the `Printf()` member function of the `RTest` class used in these examples requires a descriptor as its first parameter. Here, the `_L` macro constructs a `TPtrC` representing the constant static area generated by the compiler containing the text "\n\nThe `_L` macro constructs a `TPtrC`".

- 30 `testConsole.Printf(_L("\n\nThe _L macro constructs a TPtrC"));`

See `e32.macro._L`.

---

## TPtr

A TPtr is a modifiable pointer descriptor through which data can be modified, *provided that the data is not extended beyond the maximum length*. The maximum length is set by the constructor.

For example, define a TText area initialised to contain the string “Have a nice day”:

```

TText str[16] = {'H', 'a', 'v', 'e', ' ', 'a',
                ' ', 'n', 'i', 'c', 'e',
                ' ', 'd', 'a', 'y', '\0'};
```

- 10 A TPtr descriptor can be constructed to represent the data in this area; further, this data can be changed, contracted and expanded provided that the length of the data does not exceed the maximum.

```
TPtr ptr(&str[0],15,16);
```

- 15 The descriptor ptr represents the data in str and is constructed to have a current length of 15 (the length of the text, excluding the zero terminator) and a maximum length of 16 (the actual length of str). Once the descriptor has been constructed, it has no further use for the zero terminator.

The data can be completely replaced using the assignment operator:

```
ptr = _L("Hi there");
```

- 20 Note the use of the `_L` macro to construct a TPtrC of the correct build variant as the source of the assignment.

The length of ptr is now 8 but the maximum length remains 16. The size depends on the build variant. In an ASCII build, this is 8 but in a UNICODE build, this becomes 16 (two bytes for every character).

- 25 The length of the data represented can be changed. For example, after `ptr.SetLength(2)`, the descriptor represents the text “Hi”. The length can even be set to zero so that after `ptr.Zero()`, the descriptor represents no data. Nevertheless, the maximum length remains at 16 so that:

```
ptr = _L("Have a nice day!");
```

puts the 16 characters “Have a nice day” into the descriptor’s data area.

See also `e32.macro._L`.

---

## Buffer descriptors

`e32.descriptors.using.buffer-descriptors`

- 5 The code fragments shown here to illustrate the use of buffer descriptors are extracted from the sample source code in the `eudesbuf` project. Run the code in this project to see buffer descriptors in action.

---

### TBufC

A TBufC is a buffer descriptor where the data area is part of the descriptor itself.

- 10 Data can be set into the descriptor at construction time or by the assignment operator at *any* other time. Data already held by the descriptor cannot be modified but it can be completely replaced (again, using the assignment operator).

For example:

```
TBufC<16> bufc2(_L("Hello World!"));
```

- 15 constructs a TBufC which can contain up to 16 data items. During construction, the descriptor’s data area is set to contain the text “Hello World!” and the length of the descriptor is set to 12.

The data within `bufc2` cannot be modified but it can be replaced using the assignment operator:

- 20 `bufc2 = _L("Replacement text");`

To prevent any possibility of replacing the data, declare `bufc2` as `const`.

The data within a TBufC *can* be changed by constructing a TPtr from the TBufC using the `Des()` member function; the data can then be changed through the TPtr. The maximum length of the TPtr is the value of the TBufC template parameter. For example:

- 25 `bufc2 = _L("Hello World!");`  
`TPtr ptr = bufc2.Des();`  
`ptr.Delete((ptr.Length()-1),1);`  
`ptr.Append(_L(" & Hi"));`

This deletes the last character in the TBufC and adds the characters “ & Hi” so that the TBufC now contains the text “Hello World & Hi” and its length is 16. Note that the length of both the TBufC and the TPtr reflect the changed data.

## TBuf

5 A TBuf is a modifiable buffer descriptor where the data area is part of the descriptor itself. The data can be modified *provided that the data is not extended beyond the maximum length*. The maximum length is set by the constructor.

For example:

```
TBuf<16> buf(_L("Hello World!"));
```

10 constructs a TBuf which can contain up to 16 data items. During construction, the descriptor's data area is set to contain the text "Hello World!", the length of the descriptor is set to 12 and its maximum length is set to 16.

The data can be modified directly:

```
buf.Append('@');
```

15 changes buf's data to "Hello World!@" and its length to 13 while:

```
buf.SetLength(3);
```

changes its length to 3 and its data to “Hel”.

The maximum length of the descriptor always remains at 16.

Like a TBufC descriptor, the data contained within a TBuf can be replaced entirely using the assignment operator:

```
buf = L("Replacement text");
```

replaces “Hello World” with “Replacement text” and changes the length of the descriptor to 16.

An attempt to increase the length of the data beyond the maximum generates an exception (a panic). For example:

```
buf = _L("Text replacement causes panic!");
```

generates a panic at run time because the length of the replacement text (30) is greater than the maximum (16).

## General binary data

[e32.descriptors.using.general-binary-data](#)

The code fragments shown here, illustrating how descriptors can handle general binary data, are extracted from the sample source code in the **eudesbin** project. Run the code in this project to see the sample in action.

The kind of data represented or contained by descriptors is not restricted to text. Descriptors can also handle general binary data.

To deal with general binary data, always explicitly construct an 8 bit variant descriptor. Binary data should always be treated as 8 bit data regardless of the build.

10 For example set up an area in memory initialised with binary data:

```
TUInt8 data[6] = {0x00,0x01,0x02,0xAD,0xAE,0xAF};
```

Construct a modifiable buffer descriptor using the default constructor:

```
TBuf8<32> buffer;
```

15 The following code extracted from the **eudesbin** project puts the binary data into the descriptor, appends a number of single byte values and then displays the data at the test console. The length of the buffer is 9, the maximum length is 32 and the size is 9 regardless of the build.

```
TInt index;
```

```
TInt counter;
```

20 `buffer.Append(&data[0],sizeof(data));`

```
buffer.Append(0xFD);
```

```
buffer.Append(0xFE);
```

```
buffer.Append(0xFF);
```



```

counter = buffer.Length();
for (index = 0; index < counter; index++)
    testConsole.Printf(_L("0x%02x "),buffer[index]);

```

```

5    testConsole.Printf(_L("; Length()=%d;\n"),
        buffer.Length()
        );
    testConsole.Printf(_L("Size()=%d; MaxLength()=%d\n"),
        buffer.Size(),
10        buffer.MaxLength()
        );

```

Text and general binary data can be freely mixed; so that:

```

    buffer.Append('A');
    buffer.Append('B');
15    buffer.Append(0x11);

```

is acceptable.

---

## Non-modifying functions

### [e32.descriptors.using.non-modifying-functions](#)

The code fragments shown here, illustrating some of the non-modifying descriptor member functions, are extracted from the sample source code in the **eudesc** project. Look at the code in this project to see the full set of examples

These examples all use a TBufC descriptor constructed to contain the text “Hello World!”. Note also that the descriptor is declared const so that its data cannot be replaced using the assignment operator:

```

25    const TBufC<16> bufc(_L("Hello World!"));

```

### Right() & Mid()

These functions construct a TPtrC to represent a portion of bufc’s data.

```

    TPtrC ptrc1 = bufc.Right(5);

```

ptrc1 represents the right hand 5 data items in bufc. ptrc1's data is "orld!", its length is 5 and the address of its data area is the address of bufc's data area plus 7.

The Left() member function works in a similar way.

```
TPtrC ptrc2 = bufc.Mid(3,6);
```

- 5 ptrc2 represents the 6 data items offset 3 from the start of bufc's data area. ptrc2's data is "lo Wor", its length is 6 and the address of its data area is the address of bufc's data area plus 3.

In practice, it may not be necessary to assign the returned TPtrC to another TPtrC. For example, the following code puts a value of 3 in pos; this is the offset of char 'W' within the

- 10 chars "lo Wor" (see later for an explicit example of Locate())

```
TInt pos;
```

```
...
```

```
pos = (bufc.Mid(3,6)).Locate('W');
```

These functions can panic. For example, requesting the 13 right hand data items in bufc

- 15 will cause an exception (there are only 12):

```
TPtrC ptrc3 = bufc.Right(13);
```

### **Compare() & CompareF()**

The compare functions can be used to compare the content of two descriptors. Any kind of data can be compared. For binary data, use Compare(). For text use Compare(),

- 20 CompareF() or CompareC().

The following example compares the content of bufc with the content of a number of descriptors and displays the results at the test console:

```
...
```

```
TInt index;
```

- 25

```
...
```

```
TPtrC      genptr;
```

```
const TBufC<19> lessthan(_L(" is less than  "));
```

```
const TBufC<19> greaterthan(_L(" is greater than  "));
```

```
const TBufC<19> equalto(_L(" is equal to  "));
```

- 30

```
...
```

```

const TBufC<16> compstr[7] =    {_L("Hello World!@@"),
                                _L("Hello"),
                                _L("Hello Worl"),
                                _L("Hello World!"),
5                                _L("hello world!"),
                                _L("Hello World "),
                                _L("Hello World@" )
                                };

for (index = 0; index < 7; index++)
10    {
    if ( (bufc.Compare(compstr[index])) < 0 )
        genptr.Set(lessthan);
    else if ( (bufc.Compare(compstr[index])) > 0 )
        genptr.Set(greaterthan);
15    else genptr.Set(equalto);

    testConsole.Printf(_L("\'%S\'"\'%S\'"\'%S\'"\'n"),
                        &bufc,
                        &genptr,
20                        &compstr[index]
                        );
    }

```

The case of text is important using Compare(); the fourth comparison is equal but the fifth comparison is not (the 'w' characters are a different case).

25 Using CompareF(), the case is not important; both the fourth and fifth comparisons return an equal result.

### **Locate(), LocateF() & LocateReverse()**

The locate functions can be used to find the position (offset) of a character within text or a specific value within general binary data.

The following example attempts to find the positions (i.e. the offsets) of the characters 'H', '!', 'o' and 'w' within the text "Hello World!" and displays the result at the test console:

```

...
TInt index;
5   TInt pos;
    TPtrC genptr;

const TBufC<9> notfound(_L("NOT FOUND"));
const TBufC<5> found(_L("found"));
10  ...
    TChar ch[4] = {'H', '!', 'o', 'w'};
    ...
    testConsole.Printf(_L("using Locate() \n"));

15  for (index = 0 ; index < 4; index++)
        {
            pos = bufc.Locate(ch[index]);

            if (pos < 0)
20                genptr.Set(notfound);
            else
                genptr.Set(found);

            testConsole.Printf(_L("\n%S\ " Char %c is at pos %d (%S)\n"),
25                &bufc,
                ch[index],
                pos,
                &genptr
                );

30        }

```

The character 'w' is not found using Locate() but is found using LocateF(). This is because Locate() is case sensitive while LocateF().

This example uses LocateReverse() which is used to find the position of a character starting from the end of the descriptor's data area

```

5      ...
      testConsole.Printf(_L("using LocateReverse() \n"));

      for (index = 0 ; index < 4; index++)
      {
10         pos = bufc.LocateReverse(ch[index]);

            if (pos < 0)
                genptr.Set(notfound);
            else
15                 genptr.Set(found);

                testConsole.Printf(_L("\n%S\ " Char %c is at pos %d (%S)\n"),
                                    &bufc,
                                    ch[index],
20                 pos,
                                    &genptr
                                    );
            }
    
```

Note that the 2nd char 'o' in the string "Hello World!" is found this time.

## 25 **Match() & MatchF()**

The following example shows the use of the Match() and MatchF() member functions. The result of a matches between the content of buf and a series of descriptors with varying combinations of match strings is displayed at the test console.

...

TInt index;

TInt pos;

TPtrC genptr;

```

5  const TBufC<9> notfound(_L("NOT FOUND"));
    const TBufC<5> found(_L("found"));

    ...

    TBufC<8> matchstr[7] =    {_L("*World*"),
                                _L("*W?rld*"),
10     _L("Wor*"),
                                _L("Hello"),
                                _L("*W*"),
                                _L("hello*"),
                                _L("*")
15     };

    for (index = 0 ; index < 7; index++)
    {
        pos = bufc.Match(matchstr[index]);
        if (pos < 0)
20         genptr.Set(notfound);
        else
            genptr.Set(found);

        testConsole.Printf(_L("%- 8S  pos %2d (%S)\n"),
25         &matchstr[index],
            pos,
            &genptr

        );
    }

```

Note that when using MatchF(), the result is different when matching the 6th string where the case is ignored.

---

## Modifying functions

e32.descriptors.using.modifying-functions

- 5 The code fragments shown here, illustrating some of the modifying descriptor member functions, are extracted from the sample source code in the eudes project. Look at the code in this project to see the full set of examples.

These examples all use a TBuf descriptor constructed to contain the text “Hello World!” .:

```
TBuf<32> buf(_L("Hello World!"));
```

### 10 Swap()

The contents, length and size of altbuf1 and buf are swapped; the maximum lengths of the descriptors do NOT change.

```
TBuf<16> altbuf1(_L("What a nice day"));
```

```
...
```

15

```
buf.Swap(altbuf1);
```

### Repeat()

The current length of buf is set to 16. Repeat copying the characters “Hello” generates the text sequence “HelloHelloHelloH” in buf.

20 buf.SetLength(16);

```
buf.Repeat(_L("Hello"));
```

Setting the length of buf to and re-doing the repeat generates the text sequence “HelloHel”.

### Justify()

The example uses src as the source descriptor.

25 TBufC<40> src(\_L("Hello World!"));

```
...
```

```
buf.Justify(src,16,ELeft,'@');
```

The descriptor src has length 12.

The target field in buf has width 16 (this is greater than the length of the descriptor src). src is copied into the target field, aligned left and padded with '@' characters. The length of buf becomes the same as the specified width, i.e 16.

5        buf.Justify(src,16,ECenter,'@');

The target field in buf has width 16 (this is greater than the length of the descriptor src). src is copied into target field, aligned centrally and padded with '@' characters. The length of buf becomes the same as the specified width, i.e 16

10       buf.Justify(src,10,ECenter,'@');

The target field in buf has width 10 (this is smaller than the length of the descriptor src). src is copied into the target field but truncated to 10 characters and, therefore, alignment and padding information is not used. The length of buf becomes the same as the width, i.e. 10

15       buf.Justify(src,KDefaultJustifyWidth,ECenter,'@');

The target field in buf is set to the length of the descriptor src (whatever it currently is). src is copied into the target field. No padding and no truncation is needed and so the alignment and padding information is not used. The length of buf becomes the same as the length of src, i.e. 12.

## 20    **Descriptors as interface specifiers**

[e32.descriptors.using.interface-specifiers](#)

See the **eudesint** project for examples illustrating the use of descriptors in function interfaces.

---

## **Heap descriptors**

25    [e32.descriptors.using.heap-descriptors](#)

The code fragments shown here, illustrating the use of heap descriptors, are extracted from the sample source code in the **eudeshbc** project. Look at the code in this project to see the the sample in action.



An HBufC is always constructed on the heap using the static member functions New(), NewL() or NewLC(). For example:

```
HBufC* buf;
```

```
...
```

```
5      buf = HBufC::NewL(15);
```

This constructs an HBufC which can hold up to 15 data items. The current length is zero.

Although existing data within an HBufC cannot be modified, the assignment operator can be used to replace that data. For example:

```
*buf = _L("Hello World!");
```

10 To allow more than 15 characters or data items to be assigned into the HBufC, it must be reallocated first. For example:

```
buf = buf->ReAllocL(20);
```

This permits the following assignment to be done without causing a panic:

```
*buf = _L("Hello World! Morning");
```

15 buf may or may not point to a different location in the heap after reallocation. The location of the reallocated descriptor depends on the heap fragmentation and the size of the new cell. The Des() function returns a TPtr to the HBufC. The data in the HBufC can be modified through the TPtr. The maximum length of the TPtr is determined from the size of the cell allocated to the data area of the HBufC. For example:

```
20      TPtr ptr = buf->Des();
```

```
...
```

```
ptr.Delete((ptr.Length()-9),9);
```

```
ptr.Append(_L(" & Hi"));
```

This changes the data in the HBufC and the length of the HBufC.

---

## 25 TPtrC class Constant pointer descriptor

---

### Overview

### Derivation

TDesC     Abstract: implements descriptor behaviour which does not modify data.

TPtrC      A constant pointer descriptor.

### Defined in

e32des8.h    for the 8 bit variant (TPtr8).

e32des16.h   for the 16 bit variant (TPtr16).

### Description

- 5    Create a TPtrC descriptor to access a pre-existing location in either ROM or RAM where the data at that location is to be accessed but not changed (or where the data *cannot* be changed).

A common use for a TPtrC is to access a string of text in a code segment. This will normally be constructed using the `_L` macro which constructs a TPtrC descriptor for either an ASCII or UNICODE build.

Often, a TPtrC will appear as the right hand side of an expression or as an initialisation value for another descriptor, for example:

```
TBuf<16> str(_L("abcdefghijklmnop"));
```

```
...
```

```
15    str.Find(_L"abc");
```

```
      str.Find(_L"bcde");
```

The `_L` macro expands to a TPtrC which is defined as either a TPtrC8 or TPtrC16 depending on the build variant (TBuf is also defined in a similar way).

- 20    The 8 bit variant, TPtrC8 can be constructed to access binary data. The 8 bit variant is always explicitly used for binary data.

Five constructors are available to build a TPtrC and include a default constructor. A TPtrC can be (re-)initialised after construction by using the `set()` functions.

All the member functions described under the TDesC class are available for use by a TPtrC descriptor. In summary these are:

Length()	Fetch length of descriptor data.
Size()	Fetch the number of bytes occupied by descriptor data.
Ptr()	Return a pointer to the descriptor data.

Compare(),	Compare data (normally), (folded),(collated).
CompareF(),	
CompareC()	
Match(),MatchF(),MatchC()	Pattern match data (normally), (folded), (collated).
Locate(),LocateF()	Locate a character in forwards direction (normally), (folded).
LocateReverse(),	Locate a character in reverse direction (normally), (folded).
LocateReverseF()	
Find(),FindF(),FindC	Find data (normally), (folded), (collated).
Left()	Construct TPtrC for leftmost part of data.
Right()	Construct TPtrC for rightmost part of data.
Mid()	Construct TPtrC for portion of data.
Alloc(),AllocL(),AllocLC()	Construct an HBufC for <i>this</i> descriptor.
HufEncode()	Huffman encode
HufDecode()	Huffman decode
operators < <= > >= ==	Comparison operators
operator []	Indexing operator

---

## Construction

e32.descriptors.TPtrC.construction

---

### TPtrC() Default C++ constructor

TPtrC();

#### 5 Description

The default C++ constructor is used to construct a constant pointer descriptor.

The length of the constructed descriptor is set to zero and its pointer is set to NULL.

#### 10 Notes

Use the Set() member function to initialise the pointer descriptor.

**TPtrC()****Copy constructor**

TPtrC(const TPtrC& aDes);

**Description**

The C++ copy constructor constructs a new TPtrC object from the existing one.

- 5 The length of the constructed descriptor is set to the length of aDes and is set to point to aDes's data.

**TPtrC()****C++ constructor [with any descriptor]**

TPtrC(const TDesC& aDes);

**Description**

- 10 The C++ constructor is used to construct the TPtrC with any kind of descriptor.  
The length of the constructed descriptor is set to the length of aDes, and it is set to point to aDes's data.

**Arguments**

const TDesC& aDes      A reference to any type of descriptor used to construct the TPtrC.

**Notes**

- 15 If aDes is a reference to a heap descriptor (HBufC), then the data also resides on the heap.

**TPtrC()****C++ constructor [with zero terminated string]**

TPtrC(const TText\* aString);

**Description**

The C++ constructor is used to construct the TPtrC object with a zero terminated string.

- 20 The length of the descriptor is set to the length of the zero terminated string, excluding the zero terminator.

The constructed descriptor is set to point to the location of the string, whether in RAM or ROM.

**Arguments**

const TText\* aString      A pointer to the zero terminated used to construct the TPtrC.

**TPtrC()****C++ constructor [with address and length]**

```
TPtrC(const TUInt??* aBuf, TInt aLength);
```

**Description**

The C++ constructor is used to construct the TPtrC with the memory address and length.

- 5 The length of the constructed descriptor is set to the value of aLength.

The constructed descriptor is set to point to the memory address supplied in aBuf; the address can refer to RAM or ROM.

**Arguments**

const TUInt??\* aBuf      The address which is to be the data area of the constant pointer descriptor.

For the 8 bit variant, this is type TUInt8\*; for the 16 bit variant, this is type TUInt16\*.

TInt aLength      The length of the constructed constant pointer descriptor.  
This value must be non-negative otherwise the constructor will panic with ETDes8LengthNegative for the 8 bit variant or ETDes16LengthNegative for the 16 bit variant.

**Late initialisation**

- 10 [e32.descriptors.TPtrC.late-initialisation](#)

**Set()****Initialisation taking any descriptor**

```
void Set(const TDesC& aDes);
```

**Description**

- 15 Use this function to initialise (or re-initialise) a constant pointer descriptor using the content of any kind of descriptor.

The length of this constant pointer descriptor is set to the length of aDes.

*This* descriptor is set (or re-set) to point to aDes's data.

**Arguments**

const TDesC& aDes      A reference to any descriptor whose content is to be used to initialise *this* constant pointer descriptor.

## Notes

The Set() function can be used to initialise a constant pointer descriptor constructed using the default constructor.

If aDes is a reference to a heap descriptor (HBufC), then the data also resides on the heap.

### 5 Set() Initialisation taking address and length

```
void Set(const TUInt??* aBuf, TInt aLength);
```

Use this function to initialise (or re-initialise) a constant pointer descriptor using the supplied memory address and length.

The length of this constant pointer descriptor is set to the value of aLength.

- 10 The descriptor is set to point to the memory address supplied in aBuf; the address can refer to RAM or ROM.

## Arguments

const TUInt??\* aBuf      The address which is to be the data area of the constant pointer descriptor.

For the 8 bit variant, this is type TUInt8\*; for the 16 bit variant, this is type TUInt16\*.

TInt aLength      The length of the constant pointer descriptor.

This value must be non-negative otherwise the constructor will panic with ETDes8LengthNegative for the 8 bit variant or ETDes16LengthNegative for the 16 bit variant.

## Notes

The Set() function can be used to initialise a constant pointer descriptor constructed using the default constructor.

15

## TPtr class

## Modifiable pointer descriptor

### Overview

### Derivation

TDesC      Abstract: implements descriptor behaviour which does not modify data.

TDes Abstract: implements descriptor behaviour which can change data.

TPtr A modifiable pointer descriptor.

### Defined in

e32des8.h for the 8 bit variant (TPtr8).

e32des16.h for the 16 bit variant (TPtr16).

### Description

- 5 Create a TPtr descriptor to access a pre-existing area or buffer in RAM where the contents of that buffer are to be accessed and manipulated.

A common use for a TPtr is to access the buffer of an existing TBufC or an HBufC descriptor using the Des() member functions (of TBufC and HBufC). For example:

```
TBufC<8> str(_L("abc"));
```

10

```
str.Des().Append('x');
```

A TPtr is defined as either a TPtr8 or TPtr16 depending on the build variant and can be used to access text.

The 8 bit variant, TPtr8 can be constructed to access binary data. The 8 bit variant is always explicitly used for binary data.

15

Two constructors are available to build a TPtr and include a default constructor. A TPtr can be (re-)initialised after construction by using the set() functions.

All the member functions described under the TDesC and TDes classes are available for use by a TPtr descriptor. In summary these are:

Length()	Fetch length of descriptor data.
Size()	Fetch the number of bytes occupied by descriptor data.
Ptr()	Fetch address of descriptor data.
Compare(),	Compare data (normally), (folded),(collated).
CompareF(),	
CompareC()	
Match(), MatchF(), MatchC()	Pattern match data (normally), (folded), (collated).





Fold()	Fold characters.
Collate()	Collate characters.
LowerCase()	Convert to lower case.
UpperCase()	Convert to upper case.
Capitalise()	Capitalise.
Fill()	Fill with specified character.
FillZ()	Fill with 0x00.
Num()	Convert numerics to character (hex.digits to lower case).
NumUC()	Convert numerics to (upper case) character.
Format(), FormatList()	Convert multiple arguments to character according to format specification.
Append()	Append data.
AppendFill()	Append with fill characters.
AppendJustify()	Append data and justify
AppendNum()	Append from converted numerics.
AppendNumUC()	Append from converted numerics; convert to upper case.
AppendFormat(),	Append from converted multiple arguments.
AppendFormatList()	
ZeroTerminate()	Append zero terminator.
PtrZ()	Append zero terminator and return a pointer.
operators < <= > >= ==	Comparison operators.
operator +=	Appending operator.
operator []	Indexing operator.

---

## Construction

[e32.descriptors.TPtr.construction](#)

---

**TPtr()** **C++ constructor [with address and maximum length]**


---

TPtr(TUInt??\* aBuf,TInt aMaxLength);

**Description**

The C++ constructor is used to construct the TPtr with the address and maximum length.

- 5 The length of the constructed descriptor is set to zero and its maximum length is set to aMaxLength.

The constructed descriptor is set to point to the memory address supplied in aBuf which can refer either to RAM or ROM.

**Arguments**

TUInt??\* aBuf      The address which is to be the data area of the modifiable pointer descriptor.

For the 8 bit variant, this is type TUInt8\*; for the 16 bit variant, this is type TUInt16\*.

TInt aMaxLength      The maximum length of the new modifiable pointer descriptor.  
This value must be non-negative otherwise the constructor will panic with ETDes8MaxLengthNegative for the 8 bit variant or ETDes16MaxLengthNegative for the 16 bit variant.

---

10 **TPtr()** **C++ constructor [with address, length and maximum length]**


---

TPtr(TUInt??\* aBuf,TInt aLength,TInt aMaxLength);

**Description**

The C++ constructor is used to construct the TPtr with the address, length and maximum length.

- 15 Use this to construct a modifiable pointer descriptor using the supplied memory address, length and maximum length to initialise it.

The length of the constructed descriptor is set to aLength and its maximum length is set to aMaxLength.

- 20 The constructed descriptor is set to point to the memory address supplied in aBuf which can refer either to RAM or ROM.

## Arguments

TUint??* aBuf	<p>The address which is to be the data area of the modifiable pointer descriptor.</p> <p>For the 8 bit variant, this is type TUint8*; for the 16 bit variant, this is type TUint16*.</p>
Tint aLength	<p>The length of the new modifiable pointer descriptor.</p> <p>This value must be non-negative <i>and</i> not greater than the value of aMaxLength otherwise the constructor will panic with ETDes8LengthOutOfRange for the 8 bit variant or ETDes16LengthOutOfRange for 16 bit variant.</p>
TInt aMaxLength	<p>The maximum length of the new modifiable pointer descriptor.</p> <p>This value must be non-negative otherwise the constructor will panic with ETDes8MaxLengthNegative for the 8 bit variant or ETDes16MaxLengthNegative for 16 bit variant.</p>

---

## Late initialisation

e32.descriptors.TPtr.late-initialisation

---

### Set()

### Initialisation by copying a TPtr

5 void Set(TPtr& aPtr);

Use this function to initialise (or re-initialise) a modifiable pointer descriptor using the content of another modifiable pointer descriptor. The function behaves as a copy constructor.

10 The length of the descriptor is set to the length of aPtr and its maximum length is set to the maximum length of aPtr.

The descriptor is set (or re-set) to point to aPtr's data.

## Arguments

TPtr& aPtr	<p>A reference to a modifiable pointer descriptor whose content is to be used to initialise <i>this</i> modifiable pointer descriptor.</p>
------------	--

---

**Set()** Initialisation taking address, length and maximum length

void Set(TUInt??\* aBuf, TInt aLength, TInt aMaxLength);

Use this function to initialise (or re-initialise) a modifiable pointer descriptor using the supplied memory address, length and maximum length.

- 5 The length of the resulting descriptor is set to the value of aLength and its maximum length is set to the value of aMaxLength.

The descriptor is set (or re-set) to point to the memory address supplied in aBuf; the address can refer to RAM or ROM.

**Arguments**

TUInt??\* aBuf      The address which is to be the data area of the modifiable pointer descriptor.

For the 8 bit variant, this is type TUInt8\*; for the 16 bit variant, this is type TUInt16\*.

TInt aLength      The length of the modifiable pointer descriptor.

This value must be non-negative *and* not greater than the value of aMaxLength otherwise the constructor will panic with ETDes8LengthOutOfRange for the 8 bit variant or ETDes16LengthOutOfRange for the 16 bit variant

TInt aMaxLength      The maximum length of the modifiable pointer descriptor. This value must be non-negative otherwise the constructor will panic with ETDes8MaxLengthNegative for the 8 bit variant or ETDes16MaxLengthNegative for the 16 bit variant

---

10 **Assignment operators**

[e32.descriptors.TPtr.assignment-operators](#)

See also [e32.descriptors.TDes.assignment-operators](#).

**Operator = taking a TPtr**

### Description

5

## Arguments

### Return value

## Notes

10

**Operator = taking any descriptor**

15

### Description

20

## Arguments

### Return value

TPtr&	A reference to <i>this</i> descriptor.
-------	--

## Notes

The length of aDes must not be greater than the maximum length of *this* descriptor otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

5 **operator =** **Operator = taking a zero terminated string**

TPtr& operator=(const TText\* aString);

### Description

This assignment operator copies a zero terminated string, excluding the zero terminator, into *this* modifiable pointer descriptor.

10 The copied string replaces the existing content of *this* descriptor.

The length of *this* descriptor is set to the length of the string (excluding the zero terminator).

### Arguments

const TText\* aString      The address of the zero terminated string to be copied.

### Return value

TPtr&      A reference to *this* descriptor.

15 **Notes**

The length of the string, excluding the zero terminator, must not be greater than the maximum length of *this* descriptor otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

---

## TBufC<TInt S> class      Constant buffer descriptor

---

20 **Overview**

### Derivation

TDesC      Abstract: implements descriptor behaviour which does not modify data.

TBufCBase      Abstract: implementation convenience.

TBufC<TInt S>      A constant buffer descriptor.

### Defined in

e32des8.h      for the 8 bit variant (TBufC8<TInt S>).

e32des16.h for the 16 bit variant (TBufC16<TInt S>)

## Description

Create a TBufC descriptor to provide a buffer of *fixed* length for containing and accessing constant data.

- 5 The data held in a TBufC descriptor cannot be modified, although it can be replaced. Four constructors are available to build a TBufC descriptor and include a default constructor. The content of TBufC descriptor can be replaced after construction using the assignment operators.

For example, to create a buffer of length 16 set to contain the characters "ABC"

10 TBufC<16> str(\_L("ABC"));

The content cannot be modified but may be replaced, for example:

```
str = _L("xyz");
```

To create a buffer which is intended to contain general binary data, explicitly construct the 8 bit variant of TBufC; for example, to create a 256 byte buffer:

15 TBufC8<256> buf;

```
...
```

```
buf = ...;
```

All the member functions described under the TDesC class are available for use by a TBufC descriptor. In summary these are:

Length()	Fetch length of descriptor data.
Size()	Fetch the number of bytes occupied by descriptor data.
Ptr()	Fetch address of descriptor data.
Compare(),	Compare data (normally), (folded),(collated).
CompareF(),	
CompareC()	
Match(),MatchF(),MatchC()	Pattern match data (normally), (folded), (collated).
Locate(),LocateF()	Locate a character in forwards direction (normally), (folded).

LocateReverse(),	Locate a character in reverse direction (normally),
LocateReverseF()	(folded).
Find(),FindF(),FindC	Find data (normally), (folded), (collated).
Left()	Construct TPtrC for leftmost part of data.
Right()	Construct TPtrC for rightmost part of data.
Mid()	Construct TPtrC for portion of data.
Alloc(),AllocL(),AllocLC()	Construct an HBufC for <i>this</i> descriptor.
HufEncode()	Huffman encode
HufDecode()	Huffman decode
operators < <= > >= ==	Comparison operators
operator []	Indexing operator

---

## Construction

[e32.descriptors.TBufC.construction](#)

---

**TBufC()**

**Default C++ constructor**

TBufC();

### 5 Description

The default C++ constructor is used construct a non-modifiable buffer descriptor.

The integer template parameter <TInt S> is used, by the compiler, to calculate the size of the data area to be created as part of the descriptor object.

The length of the constructed descriptor is set to zero.

### 10 Notes

Use the assignment operators to initialise the non-modifiable buffer descriptor.

---

**TBufC()**

**Copy constructor**

TBufC(const TBufC<S>& aLcb);

### Description

15 The C++ copy constructor constructs a new TBufC<S> object from the existing one.

The integer template parameter <TInt S> is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.

aLcb's data is copied into the constructed descriptor's data area.



The length of the constructed descriptor is set to the length of aLcb.

---

**TBufC()**
**C++ constructor [with any descriptor]**

TBufC(const TDesC& aDes);

**Description**

- 5 The C++ constructor is used to construct the TBufC<S> with any kind of descriptor.
- The integer template parameter <TInt S> is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.
- aDes's data is copied into the constructed descriptor's data area.
- The length of the constructed descriptor is set to the length of aDes.

10 **Arguments**

const TDesC& aDes      A reference to any type of descriptor used to construct the TBufC<S>.

**Notes**

The length of aDes must not be greater than the value of the integer template parameter <TInt S> otherwise the constructor will panic with ETDes8LengthOutOfRange for the 8 bit variant or ETDes16LengthOutOfRange for the 16 bit variant.

15 **TBufC()**

**C++ constructor[with zero terminated string]**

TBufC(const TText\* aString);

**Description**

- The C++ constructor is used to construct the TBufC<S> with a zero terminated string.
- The integer template parameter <TInt S> is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor object.
- 20 The string, excluding the zero terminator, is copied into the constructed descriptor's data area.
- The length of the constructed descriptor is set to the length of the string, excluding the zero terminator.

25 **Arguments**

const TText\* aString      The address of the zero terminated string used to construct the TBufC<S>.

## Notes

The length of the string, excluding the zero terminator, must not be greater than the value of the integer template parameter `<TInt S>` otherwise the constructor will panic with `ETDes8LengthOutOfRange` for the 8 bit variant or `ETDes16LengthOutOfRange` for the 16 bit variant.

---

## Create a modifiable pointer descriptor

[e32.descriptors.TBufC.create-TPtr](#)

**Des()**

**Create & return a TPtr**

TPtr Des();

### Description

Use this function to construct and return a modifiable pointer descriptor to represent *this* descriptor.

The content of a non-modifiable buffer descriptor cannot be altered but creating a modifiable pointer descriptor provides a mechanism for modifying that data.

The length of the new TPtr is set to the length of *this* descriptor.

The maximum length of the new TPtr is set to the value of the integer template parameter `<TInt S>`.

The new TPtr is set to point to *this* descriptor. *This* descriptor's data is neither copied nor moved.

*This* descriptor's data can be modified through the newly constructed TPtr. If there is any change to the length of the data, then the length of both this descriptor and the TPtr is modified to reflect that change.

### Return value

TPtr      A modifiable pointer descriptor representing *this* non-modifiable buffer descriptor.

---

## Assignment operators

[e32.descriptors.TBufC.assignment-operators](#)

See also [e32.descriptors.TDes.assignment-operators](#).

**operator =****Operator = taking a TBufC<S>**

TBufC&lt;S&gt;&amp; operator=(const TBufC&lt;S&gt;&amp; aLcb);

**Description**

This assignment operator copies the content of the non-modifiable buffer descriptor aLcb into *this* non-modifiable buffer descriptor.

aLcb's data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of aLcb.

**Arguments**

const TBufC<S>& aLcb      A reference to a non-modifiable buffer descriptor whose content is to be copied.

**Return value**

TBufC<S>&      A reference to *this* descriptor.

**operator =****Operator = taking any descriptor**

TBufC&lt;S&gt;&amp; operator=(const TDesc&amp; aDes);

**Description**

This assignment operator copies the content of any type of descriptor aDes into *this* non-modifiable buffer descriptor.

aDes's data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of aDes.

**Arguments**

const TDesc& aDes      A reference to any type of descriptor whose data is to be copied.

**Return value**

TBufC<S>&      A reference to *this* descriptor.

**Notes**

The length of aDes must not be greater than the value of the integer template parameter <TInt S> otherwise the operation will panic with ETDdes8Overflow for the 8 bit variant or ETDdes16Overflow for the 16 bit variant

---

**operator =**

**Operator = taking zero terminated string**

---

TBufC<S>& operator=(const TText\* aString);

### Description

This assignment operator copies a zero terminated string, excluding the zero terminator,  
5 into *this* non-modifiable buffer descriptor.

The copied string replaces the existing content of *this* descriptor. The length of *this* descriptor is set to the length of the string, excluding the zero terminator.

### Arguments

const TText\* aString                      The address of the zero terminated string to be copied.

### Return value

TBufC<S>&                                  A reference to *this* descriptor.

### Notes

The length of the string, excluding the zero terminator, must not be greater than the value  
10 of the template parameter <TInt S> otherwise the operation will panic with  
ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

---

## TBuf<TInt S> class

## Modifiable buffer descriptor

---

### Overview

#### Derivation

TDesC                      Abstract: implements descriptor behaviour which does not modify data.

TDes                      Abstract: implements descriptor behaviour which can change data.

A modifiable buffer descriptor.

TBuf<TInt S>

#### Defined in

e32des8.h    for the 8 bit variant (TBuf<TInt S>).

e32des16.h   for the 16 bit variant (TBuf<TInt S>).

### Description

20 Create a TBuf descriptor to provide a buffer of *fixed* length for containing, accessing and  
manipulating data.

Five constructors are available to build a TBuf descriptor and include a default constructor. The content of a TBuf descriptor can be replaced after construction using the assignment operators.

For example, to create a buffer of length 8 initially set to contain the characters "ABC"

5       TBuf<8> str(\_L("ABC"));

The content of the buffer descriptor can be replaced provided the length of the new data does not exceed the value of the integer template parameter, for example:

      str = \_L("xyz");       // OK

      str = \_L("rstuvwxyz");   // causes an exception

10      To create a buffer which is intended to contain general binary data, explicitly construct the 8 bit variant TBuf8, for example, to create a 256 byte buffer:

      TBuf8<256> buf;

      ...

      buf = ...;

15

All the member functions described under the TDesC and TDes classes are available for use by a TBuf descriptor. In summary these are:

Length()	Fetch length of descriptor data.
Size()	Fetch the number of bytes occupied by descriptor data.
Ptr()	Fetch address of descriptor data.
Compare(),	Compare data (normally), (folded),(collated).
CompareF(),	
CompareC()	
Match(), MatchF(), MatchC()	Pattern match data (normally), (folded), (collated).
Locate(), LocateF()	Locate a character in forwards direction (normally), (folded).
LocateReverse(),	Locate a character in reverse direction (normally),
LocateReverseF()	(folded).
Find(), FindF(), FindC	Find data (normally), (folded), (collated).

Left()	Construct TPtrC for leftmost part of data.
Right()	Construct TPtrC for rightmost part of data.
Mid()	Construct TPtrC for portion of data.
Alloc(), AllocL(), AllocLC()	Construct an HBufC for <i>this</i> descriptor.
HufEncode()	Huffman encode
HufDecode()	Huffman decode
MaxLength()	Fetch maximum length of descriptor.
MaxSize()	Fetch maximum size of descriptor
SetLength()	Set length of descriptor data
Zero()	Set length of descriptor data to zero
SetMax()	Set length of descriptor data to the maximum value.
Swap()	Swap data between two descriptors.
Copy(), CopyF(), CopyC()	Copy data (normally), (and fold), (and collate).
CopyLC()	Copy data and convert to lower case.
CopyUC()	Copy data and convert to upper case
CopyCP()	Copy data and capitalise
Repeat()	Copy and repeat.
Justify()	Copy and justify.
Insert()	Insert data.
Delete()	Delete data.
Replace()	Replace data.
TrimLeft()	Delete spaces from left side of data area.
TrimRight()	Delete spaces from right side of data area.
Trim()	Delete spaces from both left and right side of data area.
Fold()	Fold characters.
Collate()	Collate characters.
LowerCase()	Convert to lower case.
UpperCase()	Convert to upper case.
Capitalise()	Capitalise.

Fill()	Fill with specified character.
FillZ()	Fill with 0x00.
Num()	Convert numerics to character (hex.digits to lower case).
NumUC()	Convert numerics to (upper case) character.
Format(), FormatList()	Convert multiple arguments to character according to format specification.
Append()	Append data.
AppendFill()	Append with fill characters.
AppendJustify()	Append data and justify
AppendNum()	Append from converted numerics (hex digits to lower case).
AppendNumUC()	Append from converted numerics; convert to uppercase.
AppendFormat(), AppendFormatList()	Append from converted multiple arguments.
ZeroTerminate()	Append zero terminator.
PtZ()	Append zero terminator and return a pointer.
operators < <= > >= ==	Comparison operators.
operator +=	Appending operator.
operator []	Indexing operator.

---

## Construction

[e32.descriptors.TBuf.construction](#)

---

**TBuf()**

**Default C++ constructor**

TBuf();

### 5 Description

The default C++ constructor is used to construct a modifiable buffer descriptor.

The integer template parameter <TInt S> is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.

The length of the constructed descriptor is set to zero and the maximum length is set to the value of the integer template parameter `<TInt S>`.

---

**TBuf()**
**C++ constructor[with length]**

`TBuf(TInt aLength);`

**5 Description**

The C++ constructor is used to construct the `TBuf<S>` with the length.

The integer template parameter `<TInt S>` is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.

The length of the constructed descriptor is set to `aLength` and the maximum length is set to the value of the integer template parameter `<TInt S>`.

**Arguments**

<code>TInt aLength</code>	<p>The length of the constructed modifiable buffer descriptor.</p> <p>This value must be non-negative and not greater than the value of the integer template parameter <code>&lt;TInt S&gt;</code> otherwise the constructor will panic with <code>ETDes8LengthOutOfRange</code> for the 8 bit variant or <code>ETDes16LengthOutOfRange</code> for the 16 bit variant</p>
---------------------------	---

---

**TBuf()**
**Copy constructor**

`TBuf(const TBuf<S>& aBuf);`

**Description**

15 The C++ copy constructor constructs a new `TBuf<S>` object from the existing one.

The integer template parameter `<TInt S>` is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor object.

`aBuf`'s data is copied into the constructed descriptor's data area.

The length of the constructed descriptor is set to the length of `aBuf` and the maximum length is set to the value of the integer template parameter `<TInt S>`.

---

**TBuf()**
**C++ constructor [with any descriptor]**

`TBuf(const TDesC& aDes);`

**Description**

The C++ constructor is used to construct the `TBuf<S>` with any kind of descriptor.



The integer template parameter `<TInt S>` is used ,by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.

`aDes`'s data is copied into the constructed descriptor's data area.

The length of the constructed descriptor is set to the length of `aDes` and the maximum  
5 length is set to the value of the integer template parameter `<TInt S>`.

### Arguments

`const TDesC& aDes`      A reference to any type of descriptor used to construct the  
                                 `TBuf<S>`.

### Notes

The length of `aDes` must not be greater than the value of the integer template parameter  
`<TInt S>` otherwise the constructor will panic with `ETDes8Overflow` for the 8 bit variant or  
10 `ETDes16Overflow` for the 16 bit variant

### TBuf()

### C++ constructor [with zero terminated string]

`TBuf(const TText* aString);`

### Description

The C++ constructor is used to construct the `TBuf<S>` with a zero terminated string.

15 The integer template parameter `<TInt S>` is used, by the compiler, to calculate the size of the data area to be created as part of the constructed descriptor.

The string, excluding the zero terminator, is copied into the constructed descriptor's data area.

The length of the constructed descriptor is set to the length of the string, excluding the zero  
20 terminator, and the maximum length is set to the value of the integer template parameter `<TInt S>`.

### Arguments

`const TText* aString`      The address of the zero terminated string used to  
                                 construct the `TBuf<S>`.

## Notes

The length of the string, excluding the zero terminator must not be greater than the value of the integer template parameter `<TInt S>` otherwise the constructor will panic with `ETDes8Overflow` for the 8 bit variant or `ETDes16Overflow` for the 16 bit variant

## 5 Assignment operators

[e32.descriptors.TBuf.assignment-operators](#)

See also [e32.descriptors.TDes.assignment-operators](#).

**operator =**

**Operator = taking a TBuf<S>**

`TBuf<S>& operator=(const TBuf<S>& aBuf);`

## 10 Description

This assignment operator copies the content of the modifiable buffer descriptor `aBuf` into *this* modifiable buffer descriptor.

`aBuf`'s data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of `aBuf`.

## 15 Arguments

`const TBuf<S>& aBuf`      A reference to the modifiable pointer descriptor whose content is to be copied.

## Return value

`TBuf<S>&`      A reference to *this* descriptor.

**Operator =**

**Operator = taking any descriptor**

`TBuf<S>& operator=(const TDesC& aDes);`

## Description

20 This assignment operator copies the content of any type of descriptor `aDes` into *this* modifiable buffer descriptor.

`aDes`'s data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of `aDes`.

**Arguments**

const TDesc& aDes      A reference to any type of descriptor whose content is to be copied.

**Return value**

TBuf<S>&      A reference to *this* descriptor.

**Notes**

The length of aDes must not be greater than the value of the integer template parameter  
 5 <TInt S> otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or  
 ETDes16Overflow for the 16 bit variant

---

**operator =**

**Operator = taking a zero terminated string**

TBuf<S>& operator=(const TText\* aString);

**Description**

10 This assignment operator copies a zero terminated string, excluding the zero terminator,  
 into *this* modifiable buffer descriptor.

The copied string replaces the existing content of *this* descriptor.

The length of *this* descriptor is set to the length of the string, excluding the zero terminator.

**Arguments**

const TText\* aString      The address of the zero terminated string to be copied.

15 **Return value**

TBuf<S>&      A reference to *this* descriptor.

**Notes**

The length of the string, excluding the zero terminator, must not be greater than the value  
 of the template parameter <TInt S> otherwise the operation will panic with  
 ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

20 **HBufC class**

**Heap descriptor**

---

**Overview****Derivation**

TDesC      Abstract: implements descriptor behaviour which does not modify data.

TBufCBase        Abstract: implementation convenience.

HBufC            A heap descriptor.

### Defined in

e32des8.h    for the 8 bit variant (HBufC8).

e32des16.h   for the 16 bit variant (HBufC16)

### Description

- 5    Create an HBufC descriptor to provide a buffer of *fixed* length for containing and accessing data.

The data held in an HBufC descriptor cannot be modified, although it can be replaced using the assignment operators.

- 10   The descriptor exists only on the heap but has the important property that it can be resized, i.e. made either larger or smaller, to change the size of its data area. This is achieved by reallocating the descriptor. Unlike the behaviour of dynamic buffers (see [e32.dynamic-buffers](#)), reallocation is not done automatically.

An HBufC descriptor is useful in situations where a large fixed length buffer may be required initially but, thereafter, a smaller fixed length buffer is sufficient.

- 15   An HBufC descriptor must be constructed using the static member functions New(), NewL() or NewLC() and resized using the ReAlloc() or ReAllocL() member functions. A code fragment illustrates how these might be used:

```

class CAnyClass : CBase
{
20   public :
        void AddToBuf(const TDesC& aSrcBuf);
    private :
        HBufC* iTgtBuf;
        TInt iAllocLen;
25       }

```

```

void CAnyClass::AddToBuf(const TDesC& aSrcBuf)
{
    TInt SrcLen = aSrcBuf.Length();

5      if (iTgtBuf)
        {
            if (SrcLen > iAllocLen)
                {
                    iTgtBuf = iTgtBuf->ReAllocL(SrcLen);
10             iAllocLen = SrcLen;
                }
        }
    else
        {
15         iTgtBuf = HBufC::NewL(SrcLen);
            iAllocLen = SrcLen;
        }

    *iTgtBuf = aSrcBuf;
20 }

```

In practice, the use of ReAlloc() here is a little inefficient as the data in the HBufC descriptor is saved across the re-allocation but is then discarded when the content of aSrcBuf is assigned to it.

25 All the member functions described under the TDesC class are available for use by a TBufC descriptor. In summary these are:

Length()	Fetch length of descriptor data.
Size()	Fetch the number of bytes occupied by descriptor data.
Ptr()	Fetch address of descriptor data.

Compare(),	Compare data (normally), (folded),(collated).
CompareF(),	
CompareC()	
Match(),MatchF(),MatchC()	Pattern match data (normally), (folded), (collated).
Locate(),LocateF()	Locate a character in forwards direction (normally), (folded).
LocateReverse(),	Locate a character in reverse direction (normally), (folded).
LocateReverseF()	
Find(),FindF(),FindC	Find data (normally), (folded), (collated).
Left()	Construct TPtrC for leftmost part of data.
Right()	Construct TPtrC for rightmost part of data.
Mid()	Construct TPtrC for portion of data.
Alloc(),AllocL(),AllocLC()	Construct an HBufC for <i>this</i> descriptor.
HufEncode()	Huffman encode
HufDecode()	Huffman decode
operators < <= > >= ==	Comparison operators
operator []	Indexing operator

---

## Allocation and construction

[e32.descriptors.HBufC.allocation-and-construction](#)

---

**New(), NewL(), NewLC()**

**Create new HBufC**

[e32.descriptors.new](#)

- ```

5 static HBufC* New(TInt aMaxLength);
static HBufC* NewL(TInt aMaxLength);
static HBufC* NewLC(TInt aMaxLength);

```

### Description

Use these functions to construct a new HBufC descriptor on the heap.

- 10 The functions attempt to acquire a single cell large enough to hold an HBufC object containing a data area with a length which is *at least* aMaxLength. The resulting length of

the data area *may* be larger than `aMaxLength`, depending on the way memory allocation is implemented, but is guaranteed to be *not less* than `aMaxLength`.

If there is insufficient memory available to create the descriptor, `New()` returns `NULL` but both `NewL()` and `NewLC()` leave. See [e32.exception.intro](#) for more information on leave processing.

If the new descriptor is successfully constructed, `NewLC()` will place the descriptor on the clean-up stack before returning with the address of that descriptor. See [e32.exception.transient](#) for more information on the clean-up stack.

The length of the new descriptor is set to zero.

- 10 Use operator= to assign data into the descriptor.

See example [eudeshbc](#).

### Arguments

|                              |                                                                                                                                                                                                                                                              |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>TInt aMaxLength</code> | The required length of the new descriptor's data area.<br>This value must be non-negative otherwise the function will panic with <code>ETDes8MaxLengthNegative</code> for the 8 bit variant or <code>ETDes16MaxLengthNegative</code> for the 16 bit variant. |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Return value

|                     |                                                                                                                                                                                                                                            |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>HBufC*</code> | The address of the newly created <code>HBufC</code> descriptor.<br><code>New()</code> returns <code>NULL</code> , if there is insufficient memory.<br><code>NewL()</code> and <code>NewLC()</code> leave, if there is insufficient memory. |
|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

### Example

- 15 These code fragments illustrate how an `HBufC` descriptor can be constructed.  
Use of `New()`:

```

HBufC* ptr;
...
ptr = HBufC::New(64); // buffer length is 64
if (!ptr)

```

```

5      {
          ...          // could not create the descriptor
      }

```

Use of NewL():

```

ptr = HBufC::NewL(64);
10  ...          // if control returns, allocation is OK
    ...          // and ptr has sensible value

```

---

## NewL(), NewLC()

## Create new HBufC from a stream

### e32.descriptors.newfromstream

```

static HBufC* NewL(RReadStream& aStream, TInt aMaxLength);
15 static HBufC* NewLC(RReadStream& aStream, TInt aMaxLength);

```

### Description

Use these functions to construct a new HBufC descriptor on the heap and to assign to this new descriptor, data held in the stream aStream.

The functions attempt to acquire a single cell large enough to hold an HBufC object containing a data area whose length is sufficient to contain the data held in the stream. The stream contains both the length of the data and the data itself.

If there is insufficient memory available to create the descriptor or the length value held in the stream is greater than aMaxLength, both NewL() and NewLC() leave. See [e32.exception.intro](#) for more information on leave processing.

25 If the new descriptor is successfully constructed, NewLC() places the descriptor on the clean-up stack before returning with the address of that descriptor. See [e32.exception.transient](#) for more information on the clean-up stack.

These functions assume that the stream is currently positioned at an appropriate place, i.e. a point where a descriptor has previously been streamed out (using the operator <<).



See [externalizing store.streams.externalizing.descriptors](#) and [internalizing store.streams.internalizing.descriptors](#).

For general information on streams see [store.streams-basic](#) and [store.streams](#).

For general information on stores, see [store.stores](#).

## 5 Arguments

`RReadStream& aStream` The stream from which the length of the new descriptor and the data to be assigned to the new descriptor, are to be taken.

`TInt aMaxLength` The maximum permitted length of the new descriptor. The resulting length of the new descriptor must not exceed this value, otherwise the functions leave with a `KErrOverflow`.

## Return value

`HBufC*` The address of the newly created `HBufC` descriptor. Both `NewL()` and `NewLC()` leave, if there is insufficient memory or the resulting length exceeds the value of `aMaxLength`.

---

## `NewMax()`, `NewMaxL()`, `NewMaxLC()` Create new `HBufC` and set length

```
static HBufC* NewMax(TInt aMaxLength);
```

```
static HBufC* NewMaxL(TInt aMaxLength);
```

```
10 static HBufC* NewMaxLC(TInt aMaxLength);
```

## Description

Use these functions to construct a new `HBufC` descriptor on the heap.

The functions attempt to acquire a single cell large enough to hold an `HBufC` object containing a data area with a length which is *at least* `aMaxLength`. The resulting length of the data area *may* be larger than `aMaxLength`, depending on the way memory allocation is implemented, but is guaranteed to be *not less* than `aMaxLength`.

If there is insufficient memory available to create the descriptor, `NewMax()` returns `NULL` but both `NewMaxL()` and `NewMaxLC()` leave. See [e32.exception.intro](#) for more information on leave processing.

If the new descriptor is successfully constructed, `NewMaxLC()` will place the descriptor on the clean-up stack before returning with the address of that descriptor. See [e32.exception.transient](#) for more information on the clean-up stack.

The length of the new descriptor is set to the value of `aMaxLength`.

- 5 Use operator= to assign data into the descriptor.

### Arguments

`TInt aMaxLength`      The required length of the new descriptor's data area and the length given to the descriptor.

This value must be non-negative otherwise the function will panic with `ETDes8MaxLengthNegative` for the 8 bit variant or `ETDes16MaxLengthNegative` for the 16 bit variant.

### Return value

`HBufC*`      The address of the newly created `HBufC` descriptor.  
`NewMax()` returns `NULL`, if there is insufficient memory.  
`NewMaxL()` and `NewMaxLC()` leave, if there is insufficient memory.

### Example

See [e32.descriptors.new](#) for an example

## 10 Re-allocation

[e32.descriptors.HBufC.reallocation](#)

### ReAlloc(), ReAllocL()

### Expand/contract the HBufC buffer

```
HBufC* ReAlloc(TInt aMaxLength);
```

```
HBufC* ReAllocL(TInt aMaxLength);
```

## 15 Description

Use this function to expand or contract the data area of an existing `HBufC` descriptor. This is done by:

- constructing a new `HBufC` descriptor on the heap containing a data area of length `aMaxLength`
- copying the contents of the original descriptor into the new descriptor

- 5

10

If the new descriptor is successfully constructed, then the content of the original descriptor is copied into the new descriptor, the original descriptor is deleted and the address of the new descriptor is returned to the caller. The length of the re-allocated descriptor remains unchanged.

## TInt aMaxLength

This value must be non-negative otherwise the function will panic with `ETDes8MaxLengthNegative` for the 8 bit variant or `ETDes16MaxLengthNegative` for the 16 bit variant

This value must not be less than the length of the data in the original descriptor otherwise the function will panic with `ETDes8ReAllocTooSmall` for the 8 bit variant or `ETDes16ReAllocTooSmall` for the 16 bit variant

## HBufC\*

ReAlloc() returns NULL, if there is insufficient memory.

ReAllocL() leaves, if there is insufficient memory.

## 15

Take particular care if using the `Des()` member function to create a `TPtr` descriptor. A `TPtr` descriptor created before re-allocating the `HBufC` descriptor, is not guaranteed to have a

valid pointer after re-allocation. Any attempt to modify data using the TPtr after re-allocation may have undefined consequences.

### Example

These code fragments illustrate how ReAlloc() can work.

```

5      HBufC* old;
      HBufC* newgood;
      HBufC* newbad;
      ...
      old = HBufC::NewL(16); // buffer length is 16
10     *old = _L("abcdefghijkl"); // descriptor length is 12
      ...
      newgood = old->ReAllocL(24); // first reallocation OK
      newbad = newgood->ReAllocL(8); // second reallocation panics

```

15 After the first reallocation, newgood points to the re-allocated descriptor, old contains an invalid address. The second re-allocation panics because an attempt is being made to contract the data area to a length of 8 which is smaller than the original length of the descriptor.

---

### Create a modifiable pointer descriptor

20 e32.descriptors.HBufC.create-TPtr

---

**Des()**

**Create & return a TPtr**

TPtr Des();

#### Description

25 Use this function to construct and return a modifiable pointer descriptor to represent *this* descriptor.

The content of a HBufC descriptor cannot be altered but creating a modifiable pointer descriptor provides a mechanism for modifying that data.

The length of the new TPtr is set to the length of *this* descriptor.

The maximum length of the new TPtr is set to the length of *this* descriptor's data area.

The new TPtr is set to point to *this* descriptor. *This* descriptor's data is neither copied nor moved.

*This* descriptor's data can be modified through the newly constructed TPtr. If there is any change to the length of the data, then the length of both *this* descriptor and the TPtr is modified to reflect that change.

### Return value

TPtr                      A modifiable pointer descriptor representing *this* HBufC descriptor.

### Notes

Take particular care if using ReAlloc() or ReallocL(). A TPtr descriptor created before re-allocating the HBufC descriptor, is not guaranteed to have a valid pointer after re-allocation. Any attempt to modify data using the TPtr after re-allocation may have undefined consequences.

---

## Assignment operators

[e32.descriptors.HBufC.assignment-operators](#)

See also [e32.descriptors.TDes.assignment-operators](#).

**operator =**

**Operator = taking HBufC descriptor**

HBufC& operator=(const HBufC& aLcb);

### Description

This assignment operator copies the content of the heap descriptor aLcb into *this* heap descriptor.

aLcb's data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of aLcb.

### Arguments

const HBufC& aLcb      A reference to the heap descriptor whose content is to be copied.

### Return value

HBufC&                      A reference to *this* descriptor.

## Notes

The length of the descriptor aLcb must not be greater than the length of *this* descriptor's data area otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

### 5 Operator =

**Operator = taking any descriptor**

HBufC& operator=(const TDesC& aDes);

#### Description

This assignment operator copies the content of any type of descriptor aDes into *this* heap descriptor.

- 10 aDes's data is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of aDes.

#### Arguments

|                   |                                                                      |
|-------------------|----------------------------------------------------------------------|
| const TDesC& aDes | A reference to any type of descriptor whose content is to be copied. |
|-------------------|----------------------------------------------------------------------|

#### Return value

|        |                                        |
|--------|----------------------------------------|
| HBufC& | A reference to <i>this</i> descriptor. |
|--------|----------------------------------------|

#### Notes

- 15 The length of the descriptor aDes must not be greater than the length of *this* descriptor's data area otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

### operator =

**Operator = taking zero terminated string**

HBufC& operator=(const TText\* aString);

### 20 Description

This assignment operator copies a zero terminated string, excluding the zero terminator, into *this* heap descriptor.

The string, excluding the zero terminator, is copied into *this* descriptor's data area, replacing the existing content. The length of *this* descriptor is set to the length of the string,

- 25 excluding the zero terminator.

**Arguments**

const TText\* aString           The address of the zero terminated string to be copied.

**Return value**

HBufC&                       A reference to *this* descriptor.

**Notes**

- 5   The length of the string, excluding the zero terminator, must not be greater than the length of *this* descriptor's data area otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

---

## TDesC class

---

10   **Overview**

**Derivation**

TDesC                       Abstract: implements descriptor behaviour which does not modify data.

**Defined in**

e32des8.h   for the 8 bit variant (TDesC8).

e32des16.h   for the 16 bit variant (TDesc16)

15   **Description**

The class is abstract and cannot be constructed. It implements that aspect of descriptor behaviour which does not modify the descriptor's data.

All member functions described here are available to all derived descriptor classes.

---

## Basic information

---

20   [e32.descriptors.TDesC.basic-functions](#)

**Length()**

**Fetch descriptor length**

TInt Length() const;

**Description**

Use this member function to return the number of data items in the descriptor's data area.

For example, if a descriptor data area contains one ASCII text character, the returned length is one and it occupies one byte (and the `Size()` function returns one); if a data area contains one UNICODE text character, the returned length is also one but it occupies two bytes (and the `Size()` function returns two).

|      |                                              |
|------|----------------------------------------------|
| TInt | The length of the data within the data area. |
|------|----------------------------------------------|

```
10 TInt Size() const;
```

### Return value

|    |              |                                                |
|----|--------------|------------------------------------------------|
| 15 | <b>Ptr()</b> | <b>Fetch address of descriptor's data area</b> |
|----|--------------|------------------------------------------------|

### Description

## 20 Return Value

|                |                                                                                                                           |
|----------------|---------------------------------------------------------------------------------------------------------------------------|
| const TUInt??* | The address of the data area. For the 8 bit variant, this is type TUInt8*; for the 16 bit variant, this is type TUInt16*. |
|----------------|---------------------------------------------------------------------------------------------------------------------------|

If the descriptor is used for strings, then the pointer can be regarded as a TText type and there is no need to distinguish between the 8 bit and 16 bit variants. If the descriptor is used for binary data then the pointer should be regarded as a TUint8 type.



## Comparison

[e32.descriptors.TDesC.comparison](#)

### Compare(), CompareF(), CompareC()

Compare data

TInt Compare(const TDesC& aDes) const;

5 TInt CompareF(const TDesC& aDes) const;

TInt CompareC(const TDesC& aDes) const;

### Description

Use these functions to compare the content of *this* descriptor with the content of the descriptor aDes.

10 The comparison proceeds on a byte for byte basis in the 8 bit variant and on a double-byte for double-byte basis in the 16 bit variant.

The result of the comparison is based on the difference of the first bytes (or double-bytes) to disagree. Two descriptors are equal if they have the same length and content. Where two descriptors have different lengths and the shorter matches the first part of the longer, the

15 shorter is considered to be less than the longer.

CompareF() takes the folded content of both descriptors for comparison while CompareC() takes the collated content of both descriptors for comparison. Compare() simply takes the content of both descriptors as they stand.

See [e32.descriptors.folding](#) for more information on folding and

20 [e32.descriptors.collating](#) for more information on collating.

Compare() is useful for comparing both text and binary data. CompareF() is useful for making case-insensitive text comparisons.

### Arguments

|                   |                                                                                                              |
|-------------------|--------------------------------------------------------------------------------------------------------------|
| const TDesC& aDes | A reference to any type of descriptor whose content is to be compared with <i>this</i> descriptor's content. |
|-------------------|--------------------------------------------------------------------------------------------------------------|

### Return value

|      |                                                                                                                     |
|------|---------------------------------------------------------------------------------------------------------------------|
| TInt | Positive, if <i>this</i> descriptor is greater than aDes.<br>Negative, if <i>this</i> descriptor is less than aDes. |
|------|---------------------------------------------------------------------------------------------------------------------|

Zero, if both descriptors have the same length *and* the their contents are the same.

### Example

This code fragment illustrates the use of Compare().

```
TBufC<8> str(_L("abcd"));

...

5    str.Compare(_L("abcde")); // returns -ve
    str.Compare(_L("abc"));   // returns +ve
    str.Compare(_L("abcd"));  // returns zero
    str.Compare(_L("abcx"));  // returns -ve
```

Thus:

- 10 < "abcd" is less than "abcde".
- < "abcd" is greater than "abc".
- < "abcd" is equal to "abcd".
- < "abcd" is less than "abcx".

---

## Pattern matching

- 15 [e32.descriptors.TDesC.pattern-matching](#)

---

### Match(), MatchF(), MatchC()

Pattern match data

```
TInt Match(const TDesC& aDes) const;
TInt MatchF(const TDesC& aDes) const;
TInt MatchC(const TDesC& aDes) const;
```

- 20 **Description**

Use these functions to compare the match pattern in aDes's data area against the content of *this* descriptor.

The match pattern can contain the wildcard characters '\*' and '?', where '\*' matches zero or more consecutive occurrences of any character and '?' matches a single occurrence of any character.

See [e32.descriptors.folding](#) for more information on folding and [e32.descriptors.collating](#) for more information on collating.

If the pattern terminates with an ‘\*’ wildcard character and the supplied string matches the pattern, then the value returned is the length of the string which matches the pattern up to but not including the final asterisk. This is illustrated in the examples below.

## Example

This code fragment illustrates the use of Match()

```

...
TBufC<32> str(_L("abcdefghijklmnopqrstuvwxy"));
5  ...
    str.Match(_L("*ijk*")); //returns -> 11
    str.Match(_L("*i?k*")); //    -> 11
    str.Match(_L("ijk*"));  //    -> KNotFound
    str.Match(_L("abcd"));  //    -> KNotFound
10  str.Match(_L("*i*mn*")); //    -> 14
    str.Match(_L("abcdef*")); //    -> 6
    str.Match(_L("*"));      //    -> 0

```

---

## Locate a character

[e32.descriptors.TDesC.locate-character](#)

---

### 15 **Locate(), LocateF()** **Locate a character forwards**

```

TInt Locate(TChar aChar) const;
TInt LocateF(TChar aChar) const;

```

#### **Description**

20 Use these functions to find the first occurrence of a character within *this* descriptor. The search starts at the beginning (i.e. the left side) of the data area.

LocateF() takes the folded content of the descriptor and folds the supplied character before searching. This is useful in searching for a character in a case-insensitive manner.

See [e32.descriptors.folding](#) for more information on folding.

#### **Arguments**

TChar aChar : The character to be found.

### 25 **Return value**

TInt If the character is found, this is the offset of its position from the *beginning* of the data area.

KNotFound is returned if the character is not found.

## Example

This code fragment illustrates the use of `Locate()`.

```

...
TBufC<8> str(_L("abcd"));
5  ...

str.Locate('d'); // returns 3
str.Locate('a'); // returns 0
str.Locate('b'); // returns 1
str.Locate('x'); // returns KNotFound
10 ...

```

---

### **LocateReverse(), LocateReverseF()**

**Locate a character in reverse**

TInt LocateReverse(TChar aChar) const;  
TInt LocateReverseF(TChar aChar) const;

#### **Description**

15 Use these functions to find the first occurrence of a character within *this* descriptor, searching from the back (i.e. the right side) of the data area.

LocateReverseF() takes the folded content of the descriptor and folds the supplied character before searching. This is useful in searching for a character in a case-insensitive manner.

See [e32.descriptors.folding](#) for more information on folding.

#### **Arguments**

TChar aChar      The character to be found.

#### **Return value**

TInt      If the character is found, this is the offset of its position from *beginning* of data area.  
KNotFound is returned if the character is not found.

---

### **Find data**

[e32.descriptors.TDesC.find-data](#)

**Find(), FindF(), FindC()****Find data (given by descriptor)**

TInt Find(const TDesC& aDes) const;

TInt FindF(const TDesC &aDes) const;

TInt FindC(const TDesC &aDes) const;

**5 Description**

Use these functions to find the location, within *this* descriptor, of the data supplied in aDes's. The search starts at the beginning (i.e. the left side) of *this* descriptor's data area.

FindF() folds the content of both descriptors for the purposes of searching while FindC() collates the content. See [e32.descriptors.folding](#) for more information on folding and

10 [e32.descriptors.collating](#) for more information on collating.

While these functions are most useful in searching for the existence and location of a sub-string within a string, they can, nevertheless, be used on general binary data.

FindF() is useful in performing a case-independent search of a string for a sub-string;

15 FindC() is useful in searching a string for a sub-string on the basis of their collating sequence.

**Arguments**

|                   |                                                                                                                   |
|-------------------|-------------------------------------------------------------------------------------------------------------------|
| const TDesC& aDes | A reference to any type of descriptor which contains the data sequence to be found within <i>this</i> descriptor. |
|-------------------|-------------------------------------------------------------------------------------------------------------------|

**Return value**

|      |                                                                                                                                                                                    |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt | If the data is found, the offset of the starting position of the data from the <i>beginning</i> of this descriptor's data area.<br>KNotFound is returned if the data is not found. |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Notes**

If the descriptor aDes has zero length, then the returned value will be zero.

## Example

This code fragment illustrates the use of Find().

```

...
TBufC<32> str(_L("abcdefghijklmnopqrstuvwxy"));
5  ...

    str.Find(_L("abc"));           // returns 0
    str.Find(_L("bcde"));          // returns 1
    str.Find(_L("vwxyz"));         // returns 20
    str.Find(_L("0123"));          // returns KNotFound
10  str.Find(_L("abcdefghijklmnopqrstuvwxy01")); // returns KNotFound
    str.Find(_L(""));              // returns 0
...

```

### Find(), FindF(), FindC()

### Find data (given by address and length)

```

TInt Find(const TUint??* aBuf,TInt aLen) const;
15 TInt FindF(const TUint??* aBuf,TInt aLen) const;
TInt FindC(const TUint??* aBuf,TInt aLen) const;

```

### Description

Use these functions to find the location, within *this* descriptor, of the data of length aLen at address aBuf. The search starts at the beginning (i.e. the left side) of *this* descriptor's data area.

FindF() folds the content of both *this* descriptor and the data at aBuf for the purposes of searching, while FindC() collates the content. See [e32.descriptors.folding](#) for more information on folding and [e32.descriptors.collating](#) for more information on collating.

While these functions are most useful in searching for the existence and location of a sub-string within a string, they can, nevertheless, be used on general binary data.

FindF() is useful in performing a case-independent search of a string for a sub-string; FindC() is useful in searching a string for a sub-string on the basis of their collating sequence.

## Arguments

|                     |                                                                                                                                                                                                                   |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| const TUInt??* aBuf | <p>The address of the data sequence to be found within <i>this</i> descriptor.</p> <p>For the 8 bit variant, this is type TUInt8*; for the 16 bit variant, this is type TUInt16*.</p>                             |
| TInt aLen           | <p>The length of the data sequence.</p> <p>This value must be non-negative otherwise the function will panic with ETDes8LengthNegative for the 8 bit variant or ETDes16LengthNegative for the 16 bit variant.</p> |

## Return value

|      |                                                                                                                                                                                               |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt | <p>If the data is found, the offset of the starting position of the data from the <i>beginning</i> of this descriptor's data area.</p> <p>KNotFound is returned if the data is not found.</p> |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Notes

If aLen is zero, then the returned value will be zero.

## 5 Extraction

e32.descriptors.TDesC.extraction

---

|               |                                                  |
|---------------|--------------------------------------------------|
| <b>Left()</b> | <b>Construct TPtrC for leftmost part of data</b> |
|---------------|--------------------------------------------------|

TPtrC Left(TInt aLength) const;

## Description

- 10 Use this function to construct and return a constant pointer descriptor to represent the leftmost part of *this* descriptor's data.



## Arguments

TInt aLength      The length of data within *this* descriptor which the new descriptor is to represent.

This value must not be negative and must not be greater than the current length of *this* descriptor otherwise the function will panic with ETDes8PosOutOfRange for the 8 bit variant or ETDes16PosOutOfRange for the 16 bit variant.

## Return value

TPtrC      The constant pointer descriptor representing the leftmost part of *this* descriptor's data area.

## Notes

No movement or copying of data takes place; the data represented by the returned descriptor occupies the same memory as the original.

Specifying a zero value for aLength will result in a descriptor which represents no data.

## Example

The code fragments illustrate the use of Left().

```

...
10   TBufC<8> str(_L("abcdefg"));
...           // returns a TPtrC descriptor
str.Left(4);   // representing the string
...           // "abcd"
```

The result of this specific example can be visualised in a before (shown in Figure 9) and after (shown in Figure 10) fashion. The underlined text in the “after” diagram (Figure 10) indicates the data represented by the returned descriptor.

Note that the result of the following calls to Left() will result in a panic.

5

### Construct TPtrC for rightmost part of data

### Description

- 10

|              |                                                                                            |
|--------------|--------------------------------------------------------------------------------------------|
| TInt aLength | The length of data within <i>this</i> descriptor which the new descriptor is to represent. |
|--------------|--------------------------------------------------------------------------------------------|

This value must not be negative and must not be greater than the current length of *this* descriptor otherwise the function will panic with `ETDes8PosOutOfRange` for the 8 bit variant or `ETDes16PosOutOfRange` for the 16 bit variant.

|       |                                                                                                        |
|-------|--------------------------------------------------------------------------------------------------------|
| TPtrC | The constant pointer descriptor representing the rightmost part of <i>this</i> descriptor's data area. |
|-------|--------------------------------------------------------------------------------------------------------|

## 15

Specifying a zero value for aLength will result in a descriptor which represents no data.

## Example

The code fragments illustrate the use of `Right()`.

```

...
TBufC<8> str(_L("abcdefg"));
5  ...                // returns a TPtrC descriptor
    str.Right(4);       // representing the string
    ...                // "defg"

```

The result of this specific example can be visualised in a before (Figure 11) and after (Figure 12) fashion. The underlined text in the “after” diagram (Figure 12) indicates the data represented by the returned descriptor.

Note that the result of the following calls to `Right()` will result in a panic.

```

...
TBufC<8> str(_L("abcdefg"));
15 ...
    str.Right(8);        // panic !!
    str.Right(-1);       // panic !!
    ...

```

---

## Mid() Construct TPtrC for portion of data

```

20 TPtrC Mid(TInt aPos) const;
    TPtrC Mid(TInt aPos, TInt aLength) const;

```

### Description

Use these functions to create and return a constant pointer descriptor to represent a portion of the data held in *this* descriptor.

25 The portion can be identified either by position alone or by position and length. If identified by position alone, the implied length is the length of data from the specified position to the end of the data in *this* descriptor.

## Arguments

|              |                                                                                                                                                                                                                                                                            |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aPos    | The starting position, within <i>this</i> descriptor, of the data to be represented by the new constant descriptor. The position is given relative to zero; i.e. a zero value implies the leftmost data position. This value is subject to the constraints outlined below. |
| TInt aLength | The length of data which the new descriptor is to represent. This value is subject to the constraints outlined below.                                                                                                                                                      |

If aPos alone is specified, then  $0 \leq \text{aPos} \leq \text{length of } \textit{this} \text{ descriptor}$ .

If aPos and aLength are specified, then  $0 \leq (\text{aPos} + \text{aLength}) \leq \text{length of } \textit{this} \text{ descriptor}$ .

If these limits are exceeded, then the functions will panic with ETDes8PosOutOfRange for

5 the 8 bit variant or ETDes16PosOutOfRange for the 16 bit variant.

## Return value

|       |                                                                                                     |
|-------|-----------------------------------------------------------------------------------------------------|
| TPtrC | The constant pointer descriptor representing the selected portion of <i>this</i> descriptor's data. |
|-------|-----------------------------------------------------------------------------------------------------|

## Notes

No movement or copying of data takes place; the data represented by the returned descriptor occupies the same memory as the original.

- 10 Specifying a value of aPos which has the same value as the length of the data, will result in a constant pointer descriptor which represents no data.

**Example**

The code fragments illustrate the use of Mid().

```

...
TBufC str(_L("abcdefg"));
5    ...                // returns TPtrC descriptors
                        // representing the strings...

    str.Mid(0);          //"abcdefg"
    str.Mid(1);          //"bcdefg"
10   str.Mid(6);         //"g"
    str.Mid(3,3);        //"def"
    str.Mid(0,7);        //"abcdefg"
    ...
    str.Mid(8);          // Panics !!
15   str.Mid(3,5);       // Panics!!
    ...

```

---

**Create a heap descriptor (HBufC)**

[e32.descriptors.TDesC.create-HBufC](#)

---

**Alloc(), AllocL(), AllocLC()**
**Create new HBufC for *this* descriptor**

```

20  HBufC* Alloc() const;
    HBufC* AllocL() const;
    HBufC* AllocLC() const;

```

**Description**

Use these functions to allocate and construct a new HBufC descriptor on the heap and  
 25 initialise it using the content of *this* descriptor.

The functions attempt to acquire a single cell large enough to hold an HBufC object containing a data area whose length is the same as the current length of *this* descriptor. The content of *this* descriptor is copied into the new HBufC descriptor.

If there is insufficient memory available to create the new HBufC descriptor, Alloc() returns NULL but both AllocL() and AllocLC() leave. See [e32.exception.intro](#) for more information on leave processing.

If the new descriptor is successfully created, AllocLC() will place the new descriptor on the clean-up stack before returning with the address of that descriptor. See [e32.exception.transient](#) for more information on the clean-up stack.

### Return value

HBufC\*      The address of the newly created HBufC descriptor.  
               Alloc() returns NULL, if there is insufficient memory.  
               AllocL() and AllocLC() leave, if there is insufficient memory.

### Example

The code fragments illustrate the use of AllocL().

```

10      ...
        TBufC<16> str(_L("abcdefg"));
        HBufC*  ptr;
        ...
        ptr = str.AllocL();  // Returns address of new HBufC descriptor
15      ...                // holding the string "abcdefg".
        ptr.Length();       // Returns the length 7
        ...

```

The result of this specific example can be visualised in a before (Figure 13) and after (Figure 14) fashion.

---

## Huffman Encoding/Decoding

[e32.descriptors.TDesC.huffman-encoding-decoding](#)

**HufEncode()****Huffman encode**

TInt HufEncode(TDes& aDest) const;

TInt HufEncode(TDes& aDest, const TUint8\* aHufBits) const;

**Description**

- 5 Use this function to Huffman encode the data in *this* descriptor and place the result into the descriptor aDest. The target descriptor must be a modifiable type; i.e. either a TPtr or TBuf. The caller can supply a Huffman tree or use the built-in tree.

**Arguments**

|                        |                                                                                                                                                                               |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TDes& aDest            | A reference to the modifiable descriptor which is to hold the result of encoding the data in <i>this</i> descriptor.                                                          |
| const TUint8* aHufBits | If specified, the Huffman tree to be used for encoding. This is of type TUint8* for both 8 bit and 16 bit descriptors.<br>If not supplied, the built-in Huffman tree is used. |

**Return value**

|      |                                                        |
|------|--------------------------------------------------------|
| TInt | The total number of bits occupied by the encoded data. |
|------|--------------------------------------------------------|

**HufDecode()****Huffman decode**

void HufDecode(TDes &aDest) const;

void HufDecode(TDes &aDest, const TUint8 \*aHufTree) const;

**Description**

- 15 Use this function to Huffman decode the data in *this* descriptor and place the result into the descriptor aDest. The target descriptor must be a modifiable type; i.e. either a TPtr or TBuf. The caller can supply a Huffman tree or use the built-in tree.

**Arguments**

|             |                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------|
| TDes& aDest | A reference to the descriptor which is to hold the result of decoding the data in <i>this</i> descriptor. |
|-------------|-----------------------------------------------------------------------------------------------------------|

const TUInt8\* aHufBits

If specified, the Huffman tree to be used for decoding.

This is of type TUInt8\* for both 8 bit and 16 bit descriptors.

If not supplied, the built-in Huffman tree is used.

---

## Comparison operators

[e32.descriptors.TDesC.comparison-operators](#)

**operators** < <= > >= == !=

**Comparison operators taking any descriptor**

TInt operator<(const TDesC& aDes) const;

5 TInt operator<=(const TDesC& aDes) const;

TInt operator>(const TDesC& aDes) const;

TInt operator>=(const TDesC& aDes) const;

TInt operator==(const TDesC& aDes) const;

TInt operator!=(const TDesC& aDes) const;

### 10 Description

Use these operators to determine whether the content of *this* descriptor is:

- less than
- less than or equal to
- greater than
- 15 • greater than or equal to
- equal to
- not equal to

the content of aDes.

20 The comparison is implemented using the TDesC::Compare() member function. See this member function for more detail on the comparison process.

### Arguments

const TDesC& aDes

A reference to the descriptor whose content is to be compared with the content of *this* descriptor.

### Return value

TInt

true or false



**Example**

This code fragment illustrates the use of Compare().

```
TBufC<8> str(_L("abcd"));
```

```
...
```

```
5    if (str == _L("abcde")) // returns false
```

```
    {
```

```
        ...
```

```
    }
```

```
10   if (str < _L("abcx")) // returns true
```

```
    {
```

```
        ...
```

```
    }
```

```
15   if (str > _L("abc")) // returns true
```

```
    {
```

```
        ...
```

```
    }
```

---

```
20  Indexing operator
```

[e32.descriptors.TDesC.indexing-operator](#)

---

**operator []**

**operator []**

```
const TUint??& operator[] (TInt anIndex) const;
```

**Description**

```
25  Use this operator to return a reference to a single data item within this descriptor (e.g. a text character). The data can be considered as an array of ASCII or UNICODE characters or as an array of bytes (or double-bytes) of binary data.
```

This operator allows the individual elements of the array to be accessed but *not changed*.

## Arguments

**TInt anIndex**                      The index value indicating the position of the element within the data area. The index is given relative to zero; i.e. zero implies the leftmost data position.

This value must be non-negative *and* less than the current length of the descriptor otherwise the operation will panic with `ETDes8IndexOutOfRange` for the 8 bit variant or `ETDes16IndexOutOfRange` for the 16 bit variant

## Return value

**const TUint??&**                      A reference to the data at position `anIndex`. The data is of type `TUint8&` for 8 bit variants and of type `TUint16&` for 16 bit variants.

## Example

The code fragments illustrates the use of operator[].

```

5      TBufC<8> str(_L("abcdefg"));
      ...
      str[0];           // returns reference to 'a'
      str[3];           // returns reference to 'd'
      str[7];           // Panics !!
10     if (str[0] == 'a') // ...compare returns True
        {
            ...
        }
      if (str[6] == 'x') // ...compare returns False
15     {
        ...
    }

```

---

## TDes class

---

### Overview

#### Derivation

TDesC                      Abstract: implements descriptor behaviour which does not modify data.

TDes                        Abstract: implements descriptor behaviour which can change data.

#### Defined in

- 5    e32des8.h    for the 8 bit variant (TDes8).  
      e32des16.h for the 16 bit variant (TDes16)

#### Description

The class is abstract and cannot be constructed. It implements that aspect of descriptor behaviour which modifies the descriptor's data.

- 10   All member functions described here are available to all derived descriptor classes.

---

### Basic functions

[e32.descriptors.TDes.basic-functions](#)

---

#### MaxLength()

**Fetch maximum length of descriptor**

TInt MaxLength() const;

- 15   **Description**

Use this function to return the maximum length of data that the descriptor's data area can hold.

For modifiable descriptors, the amount of data that a descriptor's data area can hold is variable; however, there is an upper limit and this limit is the value returned by the

20   function.

For 8 bit descriptors, data is single-byte valued and the maximum length has the same value as the maximum size. For 16 bit descriptors, data is double-byte valued and the value of the maximum length is half the maximum size.

#### Return value

TInt                      The maximum length of data that the descriptor's data area can hold.

---

**MaxSize()****Fetch maximum size of descriptor**

TInt MaxSize() const;

**Description**

Use this function to fetch the maximum size of the descriptor's data area, in bytes.

- 5 For 8 bit descriptors, data is single-byte and the maximum size is the same value as the maximum length.

For 16 bit descriptors, data is double-byte and the maximum size is twice the value of the maximum length.

**Return value**

TInt                      The maximum size of the descriptor's data area.

---

**Change length**

e32.descriptors.TDes.change-length

---

**SetLength()****Set length of data**

void SetLength(TInt aLength);

**Description**

- 15 Use this function to set the length of the descriptor to the value of aLength.

**Arguments**

TInt aLength              The new length of the descriptor.

This value must be non-negative and must not be greater than the maximum length otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

---

**Zero()****Set length of data to zero**

void Zero();

**Description**

- 20 Use this function to set the length of the descriptor to zero.

**SetMax()****Set length of data to maximum**

void SetMax();

**Description**

Use this function to set the length of the descriptor to its maximum value.

5 **Swap**e32.descriptors.TDes.swap**Swap()****Swap descriptor contents**

void Swap(TDes&amp; aDes);

**Description**

- 10 Swap the contents of *this* descriptor with the contents of aDes. The lengths of both descriptors are also swapped to reflect the change of data.

**Arguments**

TDes& aDes      A reference to the descriptor whose contents are to be swapped with the contents of *this* descriptor. This descriptor must be a modifiable type; i.e. either a TPtr or TBuf.

**Notes**

- 15 Each descriptor must be capable of accommodating the contents of the other descriptor. If the maximum length of a descriptor is smaller than the length of the other descriptor, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

## Example

The following code fragment illustrates the use of Swap()

```

...
TBuf<8> buf1(_L("abcde"));
5  TBuf<8> buf2(_L("xyz"));
    TBuf<16> buf3(_L("0123456789"));
...
    buf1.Swap(buf2); // contents of buf1 and buf2 swapped OK
    buf1.Swap(buf3); // Panic !!
10  ...

```

---

## Copy

e32.descriptors.TDes.copy

### Copy()

**Copy (unmodified) from any 8 bit or 16 bit descriptor**

```
void Copy(const TDesC8& aDes);
```

```
15 void Copy(const TDesC16& aDes);
```

### Description

Use these functions to copy the content of any descriptor aDes into *this* descriptor. The copied data replaces the existing content of *this* descriptor.

The length of *this* descriptor is set to the length of aDes.

20 If *this* descriptor is the 8 bit variant, Copy() is overloaded so that it can take another 8 bit descriptor or a 16 bit descriptor as source.

If *this* descriptor is the 16 bit variant, Copy() is overloaded so that it can take an 8 bit descriptor or another 16 bit descriptor as source.

Thus:

- 25 • an 8 bit descriptor can be copied to an 8 bit descriptor
- an 8 bit descriptor can be copied to a 16 bit descriptor
- a 16 bit descriptor can be copied to an 8 bit descriptor
- a 16 bit descriptor can be copied to a 16 bit descriptor

In the case where a 16 bit descriptor is copied to an 8 bit descriptor, each double-byte is copied into the corresponding single byte where the value of the double-byte is less than decimal 256. A double-byte value of 256 or greater cannot be copied and the corresponding single byte is set to a value of decimal 1.

- 5 In practice, the most common situation is to copy either 8 bit to 8 bit or 16 bit to 16 bit.

### Arguments

const TDesC8& aDes      A reference to any type of descriptor whose content is to be  
or      copied into *this* descriptor.

const TDesC16& aDes

### Notes

The length of the data in aDes cannot be greater than the maximum length of *this* descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or  
10 ETDes16Overflow for the 16 bit variant.

### Example

The code fragment illustrates the use of Copy().

...

15

TBuf<8> str;

...

str.Copy(\_L"abcdefg");      // copies "abcdefg" to tmp

str.Length();      // returns 7

str.MaxLength();      // returns 8

20

...

str.Copy(\_L"abc");      // copies "abc" to tmp

str.Length();      // returns 3

str.MaxLength();      // returns 8

...

25

str.Copy(\_L"abcdefghi");      // Panics !!

### Copy from zero terminated string

### Description

5

## Arguments

## Notes

10

**Copy from address**

### Description

15

## Arguments

For the 8 bit variant, this is type `TUInt8*`; for the 16 bit variant, this is type `TUInt16*`.

This value must be non-negative and must not be greater than maximum length of *this* descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.



**CopyF(), CopyC()****Copy (and fold/collate) from any descriptor**

```
void CopyF(const TDesC& aDes);
```

```
void CopyC(const TDesC& aDes);
```

**Description**

- 5 Use these functions to copy the content of aDesC into *this* descriptor, replacing the existing content.

The length of *this* descriptor is set to the length of aDes.

CopyF() folds the data before insertion into *this* descriptor and CopyC() collates the data before insertion.. See [e32.descriptors.folding](#) for more information on folding and

- 10 [e32.descriptors.collating](#) for more information on collating.

These functions are only of practical use for text data.

**Arguments**

const TDesC& aDes      A reference to the descriptor whose content is to be copied into *this* descriptor.

**Notes**

- 15 The length of the data in aDes must not be greater than the maximum length of *this* descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

**CopyLC(), CopyUC(), CopyCP()****Copy (and change case) from any descriptor**

```
void CopyLC(const TDesC& aDes);
```

```
void CopyUC(const TDesC& aDes);
```

- 20 void CopyCP(const TDesC& aDes);

**Description**

Use these functions to copy the content of aDesC into *this* descriptor, replacing the existing content.

The length of *this* descriptor is set to the length of aDes.

- 25 Before copying data , CopyLC() converts characters to lower case, CopyUC()converts characters to upper case and CopyCP() capitalises text.

Capitalisation means the conversion of the first character in a string to upper case and converting all remaining characters to lower case.

Accented characters retain their accents.

These functions are only of practical use for string data.

### Arguments

const TDesC& aDes      A reference to any type of descriptor whose content is to be copied into *this* descriptor.

### Notes

- 5 The length of the data in aDes must not be greater than the maximum length of *this* descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

---

## Copy repeat

[e32.descriptors.TDes.copy-repeat](#)

---

### 10 Repeat() Copy from descriptor and repeat

void Repeat(const TDesC& aDes)

#### Description

Use this function to copy the content of the descriptor aDes, repeatedly into *this* descriptor.

The copies are concatenated together within *this* descriptor and replace any existing data.

- 15 Copying proceeds until *this* descriptor is filled up to its current length. If it cannot contain a whole number of copies of aDes, then the last copy within *this* descriptor is truncated.

### Arguments

const TDes& aDes      A reference to any type of descriptor whose contents are to be repeatedly copied.

## Example

The following code fragment illustrates the use of Repeat().

```

...
TBuf<8> tgt(8);          // length of tgt is the same as the
5                          // maximum which is 8
...

                          // following strings generated in tgt
tgt.Repeat(_L("ab"));    // "abababab"
tgt.Repeat(_L("abc"));   // "abcabcab"
10 tgt.Repeat(_L("abcde")); // "abcdeabc"
...
...                      // changing length to 7 has the
                          // following effect

tgt.SetLength(7);
15 tgt.Repeat(_L("ab"));   // "abababa"
   tgt.Repeat(_L("abc"));  // "abcabca"
   tgt.Repeat(_L("abcde")); // "abcdeab"

```

### Repeat()

### Copy from address and repeat

```
void Repeat(const TUint??* aBuf, TInt aLength);
```

### Description

Use this function to copy data of length *aLength* from the memory location *aBuf*, repeatedly into *this* descriptor. The copies are concatenated together within *this* descriptor and replace any existing data.

Copying proceeds until *this* descriptor is filled up to its current length. If it cannot contain a whole number of copies, then the last copy within *this* descriptor is truncated.

### Arguments

|                     |                                                                                             |
|---------------------|---------------------------------------------------------------------------------------------|
| const TUint??* aBuf | The address of the data to be repeatedly copied.                                            |
|                     | For the 8 bit variant, this is type TUint8*; for the 16 bit variant, this is type TUint16*. |

TInt aLength                      The length of the data to be repeatedly copied.

This value must be non-negative otherwise the function will panic with ETDes8LengthNegative for the 8 bit variant or ETDes16LengthNegative for the 16 bit variant.

---

## Copy and justify

[e32.descriptors.TDes.copy-justify](#)

### Justify()

### Copy from descriptor and justify

[e32.descriptors.TDes.copy-justify.justify](#)

5    void Justify(const TDesC& aDes, TInt aWidth, TAlign anAlignment, TChar aFill);

### Description

- Use this function to copy the content of aDes into *this* descriptor, replacing the existing content. The target area is considered to be a field of width aWidth positioned at the beginning (i.e. the left hand side) of *this* descriptor's data area. The content of aDes is
- 10    copied into the target area and aligned within it as dictated by the value of anAlignment.
- If aWidth has the value KDefaultJustifyWidth, then the width of the target area (i.e. the value of aWidth) is re-set to the length of aDes.
- If the length of aDes is smaller than the width of the target area, then any spare space within the target area is padded with the fill character aFill.
- 15    If the length of aDes is greater than the width of the target area, then the amount of data copied from aDes is limited to the value of aWidth.

### Arguments

const TDesC& aDes                      A reference to any type of descriptor whose content is to be copied.

|                    |                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aWidth        | <p>The width of the target area. This must be one of:</p> <ul style="list-style-type: none"> <li>• KDefaultJustifyWidth</li> <li>• a non-negative value</li> </ul> <p>If it has the value KDefaultJustifyWidth, then it is re-set to the length of aDes.</p> <p>If the value is less than the length of aDes, then the amount of data copied from aDes into the target area is limited to aWidth.</p> |
| TAlign anAlignment | <p>An enumeration which dictates the alignment of the data within the target area. See <code>e32.enum.TAlign</code>.</p>                                                                                                                                                                                                                                                                              |
| TChar aFill        | <p>The fill character used to pad the target area.</p>                                                                                                                                                                                                                                                                                                                                                |

### Notes

If the width of the target area is greater than the maximum length of *this* descriptor, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

- 5 Do not set aWidth to a negative value (other than KDefaultJustifyWidth) as this may have unpredictable consequences.

### Example

The following code fragments illustrate the use of Justify().

```

...
10 TBuf<16> tgt(_L("abc"));
...
tgt.Justify(_L("xyz"),8,ECenter,'@');
```

The descriptor tgt has a maximum length of 16 and initially holds the string "abc". After the call to Justify(), the content of tgt changes to "@@xyz@@@" as illustrated at Figure

15 15.

In this example, the content of the source descriptor is taken to form an 8 character field which replaces the original content of the descriptor tgt. The characters "xyz" are centred within the new field and padded on both sides with the fill character '@'.

Setting the alignment to ELeft would change the content of tgt to "xyz@@@@@" while

5 setting the alignment to ERight would change the content of tgt to "@@@@@xyz"

In all three cases, the length of the descriptor tgt changes from 3 to 8.

...

TBuf<8> tgt(\_L("abc"));

10

...

tgt.Justify(\_L("xyz"),9,ECenter,'@');

This call to Justify() will panic because the resulting length of data in tgt would exceed the maximum length of tgt.

15

...

TBuf<16> tgt(\_L("abc"));

...

tgt.Justify(\_L("rstuvwxyz"),8,ECenter,'@');

In this call to Justify(), the content of tgt changes to "rstuvwxy" as illustrated at Figure 16.

20

Only eight of the nine characters in the source descriptor's data area are copied.

---

## Insertion/deletion

e32.descriptors.TDes.insertion-deletion

---

### Insert()

### Insert from descriptor

25

void Insert(TInt aPos,const TDesC& aDes);

### Description

Use this function to insert the content of aDes into *this* descriptor's data area at the specified position. The existing data at the specified position within *this* descriptor is moved to the right to make way for the inserted data.

The length of *this* descriptor is increased to reflect the increase in content.

## Arguments

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aPos         | <p>The offset within <i>this</i> descriptor's data area where the content of aDes is to be inserted. This value can range from zero to the length of <i>this</i> descriptor.</p> <p>A value of zero means insert at the beginning of <i>this</i> descriptor's data area, while a value equal to the length of <i>this</i> descriptor means insert at the end (i.e. append).</p> <p>aPos must not be negative and must not be greater than the length of <i>this</i> descriptor, otherwise the function will panic with ETDes8PosOutOfRange for the 8 bit variant or ETDes16PosOutOfRange for the 16 bit variant.</p> |
| const TDesC& aDes | <p>A reference to any type of descriptor whose content is to be inserted into <i>this</i> descriptor.</p> <p>The length of aDes plus the length of <i>this</i> descriptor must not exceed the maximum length of <i>this</i> descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.</p>                                                                                                                                                                                                                                                    |

## Example

- 5 The following code fragment illustrates the use of Insert().

```

...
TBuf<8> tgt(3);
TPtrC src(_L("abc"));
...                               // generates the strings...
10 tgt = src;
tgt.Insert(0,_L("XYZ"));          // "XYZabc"
```





## Arguments

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aPos    | <p>The offset within <i>this</i> descriptor's data area where deletion is to start. This value can range from zero to the length of <i>this</i> descriptor.</p> <p>A value of zero means delete from the beginning of <i>this</i> descriptor's data area, while a value equal to the length of <i>this</i> descriptor means, in effect, that no data will be deleted.</p> <p>aPos must not be negative and must not be greater than the length of <i>this</i> descriptor, otherwise the function will panic with ETDes8PosOutOfRange for the 8 bit variant or ETDes16PosOutOfRange for the 16 bit variant.</p> |
| TInt aLength | <p>The length of data to be deleted from the descriptor.</p> <p>If (aLength + aPos) is greater than the length of <i>this</i> descriptor, then the length of data deleted is (<i>this</i> descriptor length - aPos). In effect, the value of aLength is truncated.</p>                                                                                                                                                                                                                                                                                                                                         |

## Example

The following code fragment illustrates the use of Delete().

```

...
5   TBuf<8> tgt(4);
   TBufC<4> src(_L("abcd"));
   ...           // generates the strings
   tgt = src;
   tgt.Delete(0,1);    // "bcd"
10  ...
   tgt = src;
   tgt.Delete(0,2);    // "cd"
   ...
   tgt = src;
15  tgt.Delete(0,4);    // ""
   ...
   tgt = src;
   tgt.Delete(1,2);    // "ad"
```

```

...
tgt = src;
tgt.Delete(2,2);    // "ab"
...
5  tgt = src;
   tgt.Delete(2,3);    // "ab"
   ...
   tgt = src;
   tgt.Delete(2,256);  // "ab"
10 ...
   tgt = src;
   tgt.Delete(5,1);    // ----> Panics !!
   ...
   tgt = src;
15 tgt.Delete(-1,1);    // ----> Panics !!
   ...

```

---

### Replace()

### Replace

void Replace(TInt aPos,TInt aLength,const TDesC& aDes);

### Description

20 Use this function to replace a portion of data of length aLength in *this* descriptor's data area, starting at position aPos, with the content of the descriptor aDes.

The length of aDes may be less than aLength, in which case the resulting length of *this* descriptor decreases.

The length of aDes may be greater than aLength, in which case the resulting length of *this* descriptor increases.

25 The length of *this* descriptor changes to reflect the changed content.

## Arguments

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aPos         | <p>The offset within <i>this</i> descriptor's data area where replacement is to start. This value can range from zero to the length of <i>this</i> descriptor.</p> <p>A value of zero means replace at the beginning of <i>this</i> descriptor's data area</p> <p>aPos must not be negative and must not be greater than the length of <i>this</i> descriptor, otherwise the function panics with ETDes8PosOutOfRange for the 8 bit variant or ETDes16PosOutOfRange for the 16 bit variant.</p>                                                                                                                                                       |
| TInt aLength      | <p>The length of data in <i>this</i> descriptor which is to be replaced.</p> <p>aLength must not be negative and (aLength + aPos) must not be greater than the current length of <i>this</i> descriptor, otherwise the function panics with ETDes8LengthOutOfRange for the 8 bit variant or ETDes16LengthOutOfRange for the 16 bit variant.</p>                                                                                                                                                                                                                                                                                                       |
| const TDesC& aDes | <p>A reference to any type of descriptor whose content is to replace the data of length aLength at position aPos in <i>this</i> descriptor.</p> <p>The length of aDes must not be negative and must not exceed the maximum length of <i>this</i> descriptor otherwise the function panics with ETDes8RemoteLengthOutOfRange for the 8 bit variant or ETDes16RemoteLengthOutOfRange for the 16 bit variant.</p> <p>The resulting length of <i>this</i> descriptor must not exceed the maximum length of <i>this</i> descriptor, otherwise the function panics with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.</p> |

## Example

The following code fragment illustrates the use of Replace().

```

...
5   TBuf<8> tgt(4);
    TBufC<4> src(_L("abcd"));
    ...           // generates the strings
    tgt = src;
    tgt.Replace(0,1,_L("u")); // "ubcd"

```

```

...
tgt = src;
tgt.Replace(0,1,_L("uv")); // "uvbcd"
...
5   tgt = src;
    tgt.Replace(0,1,_L("uvw")); // "uvwbcd"
    ...
    tgt = src;
    tgt.Replace(0,1,_L("uvwxyz")); // ----> Panics !!
10  ...
    tgt = src;
    tgt.Replace(1,2,_L("u")); // "aud"
    ...
    tgt = src;
15  tgt.Replace(1,2,_L("")); // "ad"
    ...
    tgt = src;
    tgt.Replace(1,4,_L("uvw")); // ----> Panics !!
    ...
20  tgt = src;
    tgt.Replace(3,1,_L("uvw")); // "abcuvw"
    ...
    tgt = src;
    tgt.Replace(4,0,_L("uvw")); // "abcduvw"
25  ...

```

---

### Delete leading and trailing spaces

e32.descriptors.TDes.delete-spaces

**TrimLeft()****Delete spaces from left side of descriptor**

```
void TrimLeft();
```

**Description**

Use this function to delete space characters from the left hand side of the descriptor's data area. The function deletes every space character, starting at the beginning, until it meets the first non-space character.

The length of the descriptor is reduced to reflect the loss of the space characters.

**Example**

The following code fragment illustrates the use of TrimLeft().

```

10      ...
      TBuf<8> str1(_L(" abcd ")); // generates the following strings
      TBuf<8> str2(_L(" a b "));  // in the descriptors str1 and str2
      ...
      str1.Length();              // returns 8
15      str1.TrimLeft();           // "abcd "
      str1.Length();              // returns 6
      ...
      str2.Length();              // returns 5
      str2.TrimLeft();            // "a b "
20      str2.Length();             // returns 4
      ...

```

**TrimRight()****Delete spaces from right side of descriptor**

```
void TrimRight();
```

**Description**

25 Use this function to delete space characters from the right hand side of the descriptor's data area. The function deletes every space character, starting at the end and moving towards the beginning, until it meets the first non-space character.

The length of the descriptor is reduced to reflect the loss of the space characters.

### Example

The following code fragment illustrates the use of `TrimRight()`.

```

...
TBuf<8> str1(_L(" abcd ")); // generates the following strings
TBuf<8> str2(_L(" a b ")); // in the descriptors str1 and str2
...
str1.Length();           // returns 8
str1.TrimRight();        // " abcd"
str1.Length();           // returns 6
...
str2.Length();           // returns 5
str2.TrimRight();        // " a b"
str2.Length();           // returns 4
...

```

|               |                                                    |
|---------------|----------------------------------------------------|
| <b>Trim()</b> | <b>Delete spaces from both sides of descriptor</b> |
|---------------|----------------------------------------------------|

```
void Trim();
```

Use this function to delete space characters from both the left and the right hand sides of the descriptor's data area.

The function deletes every space character starting at the beginning until it meets the first non-space character and deletes every space character starting at the end and moving towards the beginning, until it meets the first non-space character.

The length of the descriptor is reduced to reflect the loss of the space characters.

**Example**

The following code fragment illustrates the use of Trim().

```

...
TBuf<8> str1(_L(" abcd ")); // generates the following strings
5  TBuf<8> str2(_L(" a b ")); // in the descriptors str1 and str2
...
str1.Length();           // returns 8
str1.Trim();             // "abcd"
str1.Length();           // returns 4
10 ...
str2.Length();           // returns 5
str2.Trim();             // "a b"
str2.Length();           // returns 3
...

```

**15 Fold/collate**

[e32.descriptors.TDes.fold-collate](#)

**Fold()****Fold**

void Fold();

**Description**

20 Use this function to fold the content of *this* descriptor. See [e32.descriptors.folding](#) for more information on folding.

**Collate()****Collate**

void Collate();

**Description**

25 Use this function to collate the content of *this* descriptor. See [e32.descriptors.collating](#) for more information on collating.

**Change case**

[e32.descriptors.TDes.change-case](#)

---

**LowerCase()****Convert to lower case**

void LowerCase();

**Description**Use this function to convert the characters in *this* descriptor to lower case.5 **UpperCase()****Convert to upper case**

void UpperCase();

**Description**Use this function to convert the characters of *this* descriptor to upper case.

---

**Capitalise()****Capitalise**

10 void Capitalise();

**Description**Use this function to capitalise the content of *this* descriptor.

Capitalisation here means the conversion of the first character to upper case and the conversion of all remaining characters to lower case.

15 **Example**

The following code fragment illustrates the use of Capitalise()

```

...
TBuf<24> tgt(_L("tHe CaT sAt On ThE mAt.));
...
tgt.Capitalise(); // changes string to
                  // "The cat sat on the mat."
...

```

---

**Filling**e32.descriptors.TDes.filling



**Fill()****Fill with character**

```
void Fill(TChar aChar);
```

**Description**

5 Use this function to fill the *this* descriptor's data area with the character aChar, replacing any existing content.

The data area is filled from the beginning up to its *current* length. It is *not* filled to its maximum length.

The length of the descriptor remains unchanged.

**Arguments**

TChar aChar                      The character used to fill the descriptor's data area.

10 **Fill()****Fill with character up to specified length**

```
void Fill(TChar aChar, TInt aLength);
```

**Description**

Use this function to fill *this* descriptor's data area with aLength characters aChar, replacing any existing content.

15 The length of the descriptor is set to aLength.

**Arguments**

TChar aChar                      The character used to fill *this* descriptor's data area.

TInt aLength                      The new length of the descriptor. This value must not be negative and must not be greater than the maximum length of *this* descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

**FillZ()****Fill with zeroes**

```
void FillZ();
```

**Description**

20 Use this function to fill the *this* descriptor's data area with zeroes (i.e. 0x00 or 0x0000), replacing any existing content.

The descriptor's data area is filled from the beginning up to its *current* length. It is *not* filled up to its maximum length.

The length of the descriptor remains unchanged.

---

## FillZ()

**Fill with zeroes up to specified length**

void FillZ(TInt aLength);

### Description

- 5 Use this function to fill the *this* descriptor's data area with aLength zeroes (i.e. 0x00 or 0x0000), replacing any existing content.

The length of the descriptor is set to aLength.

### Arguments

|              |                                                                                                                                                                                                                                                                    |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TInt aLength | The new length of the descriptor. This value must not be negative and must not be greater than the maximum length of <i>this</i> descriptor otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant. |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

---

## Integer conversion

- 10 e32.descriptors.TDes.integer-conversion

---

## Num()

**Convert signed integer**

void Num(TInt aVal);

### Description

- 15 Use this function to convert the signed integer aVal into a decimal character representation and place the resulting characters into *this* descriptor's data area, replacing any existing content. If the integer is negative, the character representation is prefixed by a minus sign.

### Arguments

|           |                                                  |
|-----------|--------------------------------------------------|
| TInt aVal | The value to be converted to decimal characters. |
|-----------|--------------------------------------------------|

## Example

The following code fragment illustrates the use of Num().

```

...
TBuf<16> tgt;           // generates the following strings
5  TInt numpos(176);     // in the descriptor tgt...
  TInt numneg(-176);
...
  tgt.Num(numpos);       // "176"
  tgt.Num(numneg);       // "-176"
10 ...

```

### Num(), NumUC()

### Convert unsigned integer

e32.descriptors.TDes.integer-conversion.Numusi

void Num(TUint aVal, TRadix aRadix=EDecimal);

void NumUC(TUint aVal, TRadix aRadix=EDecimal);

### 15 Description

Use these functions to convert the unsigned integer aVal into its corresponding character representation and place the resulting characters into *this* descriptor's data area, replacing any existing content.

Num() converts the hexadecimal characters 'a', 'b', 'c', 'd', 'e' and 'f' to lower case, while

20 NumUC() converts them to upper case.

The choice of function is dependent on the needs of applications.

### Arguments

TUint aVal            The value to be converted to characters.

TRadix aRadix        The number system representation for the unsigned integer. This is an enumeration; see e32.descriptors.TRadix.

If no value is supplied, then EDecimal is taken by default.

## Example

The following code fragment illustrates the use of Num() and NumUC().

```

...
TBuf<16> tgt;          // generates the following strings
5  TUint number(176);   // in the descriptor tgt...
...
tgt.Num(number,EBinary); // "10101010"
tgt.Num(number,EOctol);  // "252"
tgt.Num(number,EDecimal); // "176"
10 tgt.Num(number,EHex);  // "aa"  <-NB hex value in lower case
tgt.NumUC(number,EHex);  // "AA"  <-NB hex value in UPPER case
tgt.Num(number);         // "176" <--EDecimal taken as default

```

---

## Real number conversion

e32.descriptors.TDes.real-number-conversion

---

|    |              |                                      |
|----|--------------|--------------------------------------|
| 15 | <b>Num()</b> | <b>Convert floating point number</b> |
|----|--------------|--------------------------------------|

e32.descriptors.num-float

TInt Num(TReal aVal,const TRealFormat& aFormat);

### Description

Use this function to convert the floating point number aVal into a character representation and place the resulting characters into *this* descriptor's data area, replacing any existing content.

The format of the character representation is dictated by aFormat, an object of type TRealFormat. See e32.class.TRealFormat for more information on the TRealFormat class.

## Arguments

|                      |                                                                                                                                                                                         |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TReal aVal           | The floating point number to be converted. The value must be such that $1.0\text{E-}99 \leq  aVal  \leq 1.0\text{E}99$ . Any value smaller than $1.0\text{E-}99$ is assumed to be zero. |
| TRealFormat& aFormat | A reference to a TRealFormat object which dictates the format of the conversion.                                                                                                        |

### Return value

**TInt** If the conversion is successful, the length of the converted string.  
If the conversion fails, a negative value indicating the cause of failure. The possible values and their meaning are as follows:

|              |                                                                                                                                                                                                              |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| KErrArgument | The length of the converted number is greater than the maximum length of <i>this</i> descriptor. In other words, there is insufficient space in <i>this</i> descriptor to hold the character representation. |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|              |                                      |
|--------------|--------------------------------------|
| KErrOverflow | The number is too large to represent |
|--------------|--------------------------------------|

|               |                                      |
|---------------|--------------------------------------|
| KErrUnderflow | The number is too small to represent |
|---------------|--------------------------------------|

|             |                                                                                                     |
|-------------|-----------------------------------------------------------------------------------------------------|
| KErrGeneral | The conversion cannot be completed; e.g.the value of the iWidth member of TRealFormat is too small. |
|-------------|-----------------------------------------------------------------------------------------------------|

## Formatting

5 e32.descriptors.TDes.formatting

## Format()

## Convert multiple arguments

e32.descriptors.format

```
void Format(TRefByValue<const TDesC> aFmt,...);
```

### Description

10 Use this function to insert formatted text into *this* descriptor, as controlled by the format string supplied in the descriptor aFmt and the argument list which follows it. Any existing content in *this* descriptor is discarded.

The format string contained in `aFmt` contains literal text, embedded with commands for converting the trailing list of arguments into text.

The embedded commands are character sequences prefixed with the `'%'` character. The literal text is simply copied into *this* descriptor unaltered while the `'%'` commands are used to convert successive arguments (which follow `aFmt` in the argument list).

The resulting stream of literal text and converted arguments is inserted into *this* descriptor.

The syntax of the embedded commands follows one of the four general patterns shown below. Each bracketed item indicates a character or sequence of characters having a specific meaning.

10 A bracketed item within square brackets is optional.

- `%<type>`

where `<type>` is a character code which indicates how data is to be converted.

The data is converted without padding and only occupies the space required.

- `%<width>[<prec>]<type>`

15 where `<type>` is a character code indicating how data is to be converted and `<width>` contains either numeric characters which directly define the size of the field to be occupied by the converted data or an `'*'` character. An `'*'` indicates that the size of the field is taken from the next `TUint` value in the argument list.

`<prec>` is optional and is only relevant when a real number is to be converted.

20 If specified, `<prec>` must be a `'.'` character followed by an integer representing the precision of the real number, (i.e. the number of decimal places). If `<prec>` is omitted, the precision for the conversion of a real number defaults to `KDefaultPrecision`.

25 The converted data is right-aligned within the field; if it occupies fewer character positions than specified in `<width>`, it is padded to the left with blank characters.

If more than `<width>` characters are generated by the conversion, then the outcome depends on the value of `<type>`.

If <type> is either e, E, f, or F, (the source data is a real number), the value of <width> is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed KMaxRealWidth.

If <type> is either g, or G, (the source data is a real number), the value of <width> is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed KDefaultRealWidth.

If the source data is any other type, the converted data is truncated so that only <width> characters are taken.

• %0<width>[<prec>]<type>

where <type> is a character code indicating how data is to be converted and <width> contains numeric characters which directly define the size of the field to be occupied by the converted data.

The converted data is right-aligned within this field; if it occupies fewer character positions than specified in <width>, it is padded to the left with '0' characters.

If more than <width> characters are generated by the conversion, then the outcome depends on the value of <type>.

If <type> is either e, E, f, or F, (the source data is a real number), the value of <width> is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed KMaxRealWidth.

If <type> is either g, or G, (the source data is a real number), the value of <width> is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed KDefaultRealWidth.

If the source data is any other type, the converted data is truncated so that only <width> characters are taken.

<prec> is optional and is only relevant when a real number is to be converted.

If specified, <prec> must be a '.' character followed by an integer representing

the precision of the real number, (i.e. the number of decimal places). If `<prec>` is omitted, the precision for the conversion of a real number defaults to `KDefaultPrecision`.

(Note: in this specific case, `<width>` cannot be a single `*` character. If it is necessary to take the width value from the argument list, use the more general pattern `%<a><p><width><type>`).

- `%<a><p><width>[<prec>]<type>`

where `<type>` is a character code indicating how data is to be converted and `<width>` contains either numeric characters which directly define the size of the field to be occupied by the converted data or an `*` character. An `*` indicates that the size of the field is taken from the next `TUint` value in the argument list.

`<prec>` is optional and is only relevant when a real number is to be converted. If specified, `<prec>` must be a `.` character followed by an integer representing the precision of the real number, (i.e. the number of decimal places). If `<prec>` is omitted, the precision for the conversion of a real number defaults to `KDefaultPrecision`.

The converted data is aligned within this field as defined by the value of `<a>` as follows:

- + right aligned
- left aligned
- = centre aligned

If the converted data occupies fewer character positions than specified in `<width>`, it is padded with the pad character defined by `<p>`.

Note that a pad character of `*` is a special case. It indicates that the code value of the pad character is taken from the next `TUint` value in the argument list. The data for conversion is taken from the *following* argument.

Thus, to pad with asterisks, the code value of the asterisk character must be supplied through the argument list.



If more than `<width>` characters are generated by the conversion, then the outcome depends on the value of `<type>`.

If `<type>` is either `e`, `E`, `f`, or `F`, (the source data is a real number), the value of `<width>` is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed `KMaxRealWidth`.

If `<type>` is either `g`, or `G`, (the source data is a real number), the value of `<width>` is ignored and all the generated characters are accepted; however, the maximum number of characters generated can never exceed `KDefaultRealWidth`.

If the source data is any other type, the converted data is truncated so that only `<width>` characters are taken.

The conversion of argument data is dictated by the value of `<type>` which consists of a single character. Note the case of the character as this is significant.

The possible values for `<type>` are as follows:

- b Interpret the argument as a `TUint` and convert it to its binary character representation. This can be either upper or lower case.
- o Interpret the argument as a `TUint` and convert it to its octal character representation. This can be either upper or lower case.
- d Interpret the argument as a `TInt` and convert it to its *signed* decimal representation. This can be either upper or lower case.  
If the value is negative, the representation will be prefixed by a minus sign.
- e Interpret the argument as a `TReal` and convert it to exponent format representation (See `e32.class.TRealFormat` and `e32.enum.TRealFormatType`).  
(Note the *lower* case)
- E Interpret the argument as a `TReal96` and convert it to exponent format representation (See `e32.class.TRealFormat` and `e32.enum.TRealFormatType`).  
(Note the *upper* case)

- f Interpret the argument as a TReal and convert it to fixed format representation  
(See `e32.class.TRealFormat` and `e32.enum.TRealFormatType`).  
(Note the *lower* case)
- F Interpret the argument as a TReal96 and convert it to fixed format  
representation (See `e32.class.TRealFormat` and  
`e32.enum.TRealFormatType`).  
(Note the *upper* case)
- g Interpret the argument as a TReal and convert it to either fixed or exponent  
format representation, whichever format can present the greater number of  
significant digits (See `e32.class.TRealFormat` and  
`e32.enum.TRealFormatType`).  
(Note the *lower* case)
- G Interpret the argument as a TReal96 and convert it to either fixed or exponent  
format representation, whichever format can present the greater number of  
significant digits (See `e32.class.TRealFormat` and  
`e32.enum.TRealFormatType`).  
(Note the *upper* case)
- u Interpret the argument as a TUint and convert it to its *unsigned* decimal  
representation. This can be either upper or lower case.
- x Interpret the argument as a TUint and convert it to its hexadecimal  
representation. This can be either upper or lower case.
- p Generate the required number of pad characters. No arguments are accessed.  
This can be either upper or lower case.
- c Interpret the argument as a TUint value and convert it to a single ASCII  
character value. This can be either upper or lower case.
- s Interpret the argument as a zero terminated string. Copy the characters from the  
string but exclude the zero terminator.  
(Note the *lower* case).

- S Interpret the argument as the *address* of a descriptor and copy the characters from it.  
(Note the *upper* case).
- w Interpret the argument as a TUint and convert the value to a *two byte* binary numeric representation with the *least* significant byte first. The generated output is two bytes whether *this* descriptor is an 8 bit or a 16 bit variant.  
(Note the *lower* case).
- W Interpret the argument as a TUint and convert the value to a *four byte* binary numeric representation with the *least* significant byte first. The generated output is four bytes whether this descriptor is an 8 bit or a 16 bit variant.  
(Note the *upper* case).
- m Interpret the argument as a TUint and convert the value to a *two byte* binary numeric representation with the *most* significant byte first. The generated output is two bytes whether this descriptor is an 8 bit or a 16 bit variant.  
(Note the *lower* case)..
- M Interpret the argument as a TUint and convert the value to a *four byte* binary numeric representation with the *most* significant byte first. The generated output is four bytes whether this descriptor is an 8 bit or a 16 bit variant.  
(Note the *upper* case).

## Arguments

- |                               |                                                                                                    |
|-------------------------------|----------------------------------------------------------------------------------------------------|
| TRefByValue<const TDesC> aFmt | Any type of descriptor containing the format string. The TRefByValue is constructed from the aFmt. |
| ...                           | A variable number of arguments to be converted to text as dictated by the format string in aFmt.   |

## Notes

Two successive '%' characters are interpreted as literal text and causes one '%' character to

5 be generated.

Blank characters are interpreted as literal text.

Specifying a pad character of '\*' is a special case. It indicates that the code value of the pad character is taken as the *next* TUint value from the argument list. Any data needed for conversion is taken from the *following* argument.

- 5 Thus, to use asterisks as a pad character, the code value of the asterisk character must be supplied in the argument list.

Using an '\*' character for both <width> and <p> means that the width value and the pad character will be taken from the argument list. Note that the first '\*' character will be interpreted as representing the width *only* if it is preceded by one of the alignment characters '+', '-', or '=' (i.e., if the command follows the fourth general pattern outlined above).

Specifying the command %p results in no characters being generated. To be useful, a width needs to be specified; for example '%1p' or '%6p'.

If <prec> is specified when the data to be converted is not a real number, then it is ignored.

- 15 If any command has incorrect syntax, then the function will panic with ETDes8BadFormatDescriptor for the 8 bit variant or ETDes16BadFormatDescriptor for the 16 bit variant

If the resulting length of text in *this* descriptor exceeds its maximum length, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the

- 20 16 bit variant.

### Example

The following code fragments illustrate the various possibilities of Format().

```
...
TBuf<256> tgt;
25 ...
tgt.Format(_L("[%b %c %d %o %u %x]"),65,65,65,65,65,65);
... //generates:
//[1000001 A 65 101 65 41]
```

```
tgt.Format(_L("[%04x]"),65;
```

```
...           //generates:
               //[0041]
```

```
5  tgt.Format(_L("[%4x]"),65;
```

```
...           //generates:
               //[ 41]
               //    note the use of blanks as
               //    default fill characters
```

```
10
```

```
tgt.Format(_L("[%*x]"),4,65;
```

```
...           //generates:
               //[ 41]
               //    width taken from the
15          //    argument list
```

```
tgt.Format(_L("[%+$4d.00 %S]"),65,&(_L("over")));
```

```
...           //generates:
               //[$$65.00 over]
20          //    note that %ls can be
               //    replaced by %S
```

```
tgt.Format(_L("[%+0*S]"),10,&(_L("fred")));
```

```
...           //generates:
25          //[000000fred]
```

```
tgt.Format(_L("[%=*6x]"),'*',65);
```

```
...           //generates:
               //[**41**]
```

```
30
```

```
... //generates:
//[.....-65]
```

```
... //generates:
    //[AAAA]
```

10

```
... //generates:
    //the charac
```

15

```
... //generates:
//the charac
```

20

```
//followed by the character ']'
```

```
tgt.Format(_L("[%w]"),4660);
```

```
...           //generates:
               //the character '['
               //followed by a byte holding 0x34
5             //followed by a byte holding 0x12
               //followed by the character ']'
```

```
tgt.Format(_L("[%W]"),4660);
```

```
...           //generates:
10            //the character '['
               //followed by a byte holding 0x34
               //followed by a byte holding 0x12
               //followed by a byte holding 0x00
               //followed by a byte holding 0x00
15            //followed by the character ']'
```

```
tgt.Format(_L("[%6.2e]"),3.4555);
```

```
...           //generates:
               //[3.46E+00]
20
```

```
tgt.Format(_L("[%6.2f]"),3.4555);
```

```
...           //generates:
               //[ 3.46]
```

```
25 tgt.Format(_L("[%6.2g]"),3.4555);
```

```
...           //generates:
               //[3.4555]
```

**FormatList()****Convert multiple arguments**

```
void FormatList(const TDesC& aFmt, VA_LIST aList);
```

**Description**

This function is equivalent to Format().

**5 Arguments**

const TDesC& aFmt      A reference to any type of descriptor containing the format string.

VA\_LIST aList          A pointer to a variable number of arguments to be converted to text as dictated by the format string in aFmt.

---

**Appending**

e32.descriptors.TDes.appending

**10 Append()****Append a character**

```
void Append(TChar aChar);
```

**Description**

Use this function to add a character onto the end of the content of *this* descriptor.

The length of *this* descriptor is incremented by one.

**15 Arguments**

TChar aChar            The character to be appended.

**Notes**

The length of *this* descriptor must be less than its maximum length. If the descriptor is already at its maximum length, any attempt to append another character will cause the function to panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the

20    16 bit variant.



**Append()****Append any descriptor**

```
void Append(const TDesC& aDes);
```

**Description**

Use this function to append the content of aDes onto the end of the content of *this* descriptor.

The length of *this* descriptor is incremented by the length of aDes.

There is an extra overloaded variation of Append() so that, if *this* descriptor is the 8 bit variant, Append() can take the 16 bit variant of aDes as well as the expected 8 bit variant.

Thus:

- an 8 bit descriptor can be appended onto an 8 bit descriptor
- a 16 bit descriptor can be appended onto a 16 bit descriptor
- a 16 bit descriptor can be appended onto an 8 bit descriptor.

In the case where a 16 bit descriptor is appended to an 8 bit descriptor, each double-byte is appended as a single byte where the value of the double-byte is less than decimal 256. A double-byte value of decimal 256 or greater cannot be appended as a single byte value and, in this case, the single byte is set to a value of decimal 1.

**Arguments**

const TDesC& aDes      A reference to any type of descriptor whose content is to be appended.

**Notes**

The resulting length of *this* descriptor must not be greater than its maximum length otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant

**Append()****Append from address**

```
void Append(const TUint??* aBuf, Tint aLength);
```

**Description**

Use this function to append data of length aLength at address aBuf onto the end of the content of *this* descriptor.

The length of *this* descriptor is incremented by the value of aLength.

**Arguments**

const TUInt??\* aBuf                      The address of the data to be appended.  
                                             For the 8 bit variant, this is type TUInt8\*; for the 16 bit  
                                             variant, this is type TUInt16\*.

TInt aLength                              The length of the data to be appended.

**Notes**

The resulting length of *this* descriptor must not be greater than its maximum length  
 otherwise the function will panic with ETDes8Overflow for the 8 bit variant or  
 5 ETDes16Overflow for the 16 bit variant.

The value of aLength must be non-negative otherwise the results may be unpredictable.

**AppendFill()****Append with fill characters**

void AppendFill(TChar aChar,TInt aLength);

**Description**

10 Use this function to add aLength characters aChar onto the end of any existing data in *this*  
 descriptor.

**Arguments**

TChar aChar                              The fill character.

TInt aLength                              The number of fill characters to be appended.

**Notes**

The resulting length of *this* descriptor must not be greater than its maximum length  
 15 otherwise the function will panic with ETDes8Overflow for the 8 bit variant or  
 ETDes16Overflow for the 16 bit variant

**AppendJustify()****Append any descriptor and justify**

e32.descriptors.TDes.appending.appendjustify-anydesc

void AppendJustify(const TDesC& aDes,TInt aWidth,  
 20                      TAlign anAlignment,TChar aFill);

**Description**

Use this function to copy the content of aDes onto the end of the content of *this* descriptor.

The target area within *this* descriptor is considered to be an area of width `aWidth`, immediately following the existing data. The source data is copied into this target area and aligned within it as dictated by the value of `anAlignment`.

If `aWidth` has the value `KDefaultJustifyWidth`, then the width of the target area (i.e. the value of `aWidth`) is re-set to the value of `aLength`.

If `aLength` is smaller than the width of the target area, then any spare space within the target area is padded with the fill character `aFill`.

If `aLength` is greater than the width of the target area, then the amount of data copied from the location `aString` is limited to the value of `aWidth`.

## 10 Arguments

`const TDesC& aDes` A reference to any type of descriptor whose content is to be copied.

`TInt aWidth` The width of the target area. This must be one of:

- `KDefaultJustifyWidth`
- a non-negative value

If it has the value `KDefaultJustifyWidth`, then it is re-set to the length of `aDes`.

If the value is less than the length of `aDes`, then the amount of data copied from `aDes` into the target area is limited to this value.

`TAlign anAlignment` An enumeration which dictates the alignment of the data within the target area. See [e32.enum.TAlign](#).

`TChar aFill` The fill character used to pad the target area.

## Notes

If the width of the target area is greater than the maximum length of *this* descriptor, then the function will panic with `ETDes8Overflow` for the 8 bit variant or `ETDes16Overflow` for the 16 bit variant.

15 Do not set `aWidth` to a negative value (other than `KDefaultJustifyWidth`) as this may have unpredictable consequences.

## Example

The following code fragments illustrate the use of `AppendJustify()`.

...

```
TBuf<16> tgt(_L("abc"));
```

```
5    tgt.AppendJustify(_L("xyz"),8,ECenter,'@');
```

The descriptor `tgt` has a maximum length of 16 and initially holds the string "abc". After the call to `AppendJustify()`, the content of `tgt` changes to "abc@@@xyz@@@" as illustrated at Figure 17.

10 In this example, the content of the source descriptor is taken to form an 8 character field which is appended to the content of the descriptor `tgt`. The characters "xyz" are centred within the new field and padded on both sides with the fill character '@'.

Setting the alignment to `ELeft` would change the content of `tmp` to "abcxyz@@@@@"

15 while setting the alignment to `ERight` would change the content of `tmp` to "abc@@@@@xyz"

In all three cases, the length of the descriptor `tgt` changes from 3 to 11.

...

```
20    TBuf<16> tgt(_L("abcdefghik"));
```

```
    tgt.AppendJustify(_L("0123456"),7,ECenter,'@');
```

This call to `AppendJustify()` will panic because the resulting length of `tgt` would exceed its maximum length.

---

**AppendJustify()**

**Append part of any descriptor and justify**

25 e32.descriptors.TDes.appending.appendjustify-partdesc

```
void AppendJustify(const TDesC &Des, Tint aLength, Tint aWidth,
                  TAlign anAlignment, TChar aFill);
```

## Description

Use this function to append data of length `aLength` from the descriptor `aDes` onto the end of the content of *this* descriptor.

The target area within *this* descriptor's data area is considered to be an area of width `aWidth`, immediately following the existing data. The source data is copied into this target area and aligned within it as dictated by the value of `anAlignment`.

If `aWidth` has the value `KDefaultJustifyWidth`, then the width of the target area (i.e. the value of `aWidth`) is re-set to the value of `aLength`.

If `aLength` is smaller than the width of the target area, then any spare space within the target area is padded with the fill character `aFill`.

If `aLength` is greater than the width of the target area, then the amount of data copied from `aDes` is limited to the value of `aWidth`.

## Arguments

`const TDesC& aDes`      A reference to any type of descriptor whose content is to be copied.

`Tint aLength`      The length of data to be copied from the source descriptor `aDes`.  
If this value is greater than the value of `aWidth`, then it is truncated to the value of `aWidth`.

`Tint aWidth`      The width of the target area. This must be one of:  
    < `KDefaultJustifyWidth`  
    < a non-negative value  
If it has the value `KDefaultJustifyWidth`, then it is re-set to the value of `aLength`.  
If this value is less than `aLength`, then the amount of data copied from `aDes` is limited to `aWidth`.

`TAlign anAlignment`      An enumeration which dictates the alignment of the data within the target area. See `e32.enum.TAlign`.

TChar aFill

The fill character used to pad the target area.

## Notes

If the width of the target area is greater than the maximum length of *this* descriptor, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

- 5 Do not set aWidth to a negative value (other than KDefaultJustifyWidth) as this may have unpredictable consequences.

Do not set aLength to a negative value as this may have unpredictable consequences.

Make sure that the value of aLength is not greater than the length of aDes otherwise unexpected data may be copied.

## 10 Example

The following code fragments illustrate the use of AppendJustify().

...

```
TBuf<16> tgt(_L("abc"));
```

```
tgt.AppendJustify(_L("xyz01234456789"),3,8,ECenter,'@');
```

- 15 The descriptor tgt has a maximum length of 16 and initially holds the string "abc". After the call to AppendJustify(), the content of tgt changes to "abc@@xyz@@@" as illustrated at Figure 18.

In this example, the first three characters of \_L"xyz0123456789" are taken to form an 8 character field which is appended to the existing content of the descriptor tgt. The characters "xyz" are centred within the new field and padded on both sides with the fill character '@'.

- 20 Setting the alignment to ELeft would change the content of tgt to "abcxyz@@@@@@" while setting the alignment to ERight would change the content of tgt to
- 25 "abc@@@@@xyz"

In all three cases, the length of the descriptor tgt changes from 3 to 11.

```
...
TBuf<16> tgt(_L("abc"));
tgt.AppendJustify(_L"0123456789",9,8,ECenter,'@');
```

In this example, the call to `AppendJustify()` changes the content of `tgt` to `"abc01234567"`.

- 5 As the specified length is greater than the specified width, the length is truncated so that only eight characters are copied from the source descriptor.

```
...
TBuf<16> tgt(_L("abcdefghik"));
10 tgt.AppendJustify(_L"0123456789",3,7,ECenter,'@');
```

This call to `AppendJustify()` panics because the resulting length of `tgt` would exceed its maximum length.

---

## AppendJustify()

## Append from address and justify

e32.descriptors.TDes.appending.appendjustify-fromadr

- 15 void AppendJustify(const TUint??\* aString, TInt aLength, TInt aWidth,  
TAlign anAlignment, TChar aFill);

### Description

Use this function to append data of length `aLength` from the address `aString` onto the end of the content of *this* descriptor.

- 20 The target area within *this* descriptor's data area is considered to be an area of width `aWidth`, immediately following the existing data. The source data is copied into this target area and aligned within it as dictated by the value of `anAlignment`.

If `aWidth` has the value `KDefaultJustifyWidth`, then the width of the target area (i.e. the value of `aWidth`) is re-set to the value of `aLength`.

- 25 If `aLength` is smaller than the width of the target area, then any spare space within the target area is padded with the fill character `aFill`.

If `aLength` is greater than the width of the target area, then the amount of data copied from the location `aString` is limited to the value of `aWidth`.

## Arguments

|                     |                                                                                                                                                                                                                                                                                                                                                                                          |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| const TUInt??* aBuf | <p>The address of the data to be copied and appended.</p> <p>For the 8 bit variant, this is type TUInt8*; for the 16 bit variant, this is type TUInt16*.</p>                                                                                                                                                                                                                             |
| TInt aLength        | <p>The length of data to be copied from the location aString.</p> <p>If this value is greater then the value of aWidth, then it is truncated to the value of aWidth.</p>                                                                                                                                                                                                                 |
| TInt aWidth         | <p>The width of the target area. This must be one of:</p> <ul style="list-style-type: none"> <li>• KDefaultJustifyWidth</li> <li>• a non-negative value</li> </ul> <p>If it has the value KDefaultJustifyWidth, then it is re-set to the value of aLength.</p> <p>If this value is less than aLength, then the amount of data copied from the location aString is limited to aWidth.</p> |
| TAlign anAlignment  | <p>An enumeration which dictates the alignment of the data within the target area. See <a href="#">e32.enum.TAlign</a>.</p>                                                                                                                                                                                                                                                              |
| TChar aFill         | <p>The fill character used to pad the target area.</p>                                                                                                                                                                                                                                                                                                                                   |

## Notes

If the width of the target area is greater than the maximum length of *this* descriptor, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

Do not set aWidth to a negative value (other than KDefaultJustifyWidth) as this may have unpredictable consequences.

Do not set aLength to a negative value as this may have unpredictable consequences.

## AppendJustify()

## Append zero terminated string and justify

[e32.descriptors.TDes.appending.appendjustify-zeroterm](#)



```
void AppendJustify(const TText* aString, TInt aWidth,
                  TAlign anAlignment, TChar aFill);
```

### Description

Use this function to append the zero terminated string, located at `aString`, onto the end of the content of *this* descriptor. The zero terminator is not copied.

The target area within *this* descriptor's data area is considered to be an area of width `aWidth`, immediately following the existing data. The zero terminated string is copied into this target area and aligned within it as dictated by the value of `anAlignment`.

If `aWidth` has the value `KDefaultJustifyWidth`, then the width of the target area (i.e. the value of `aWidth`) is re-set to the length of the zero terminated string, excluding the zero terminator.

If the length of the zero terminated string (excluding the zero terminator) is smaller than the width of the target area, then any spare space within the target area is padded with the fill character `aFill`.

If the length of the zero terminated string (excluding the zero terminator) is greater than the width of the target area, then the number of characters copied from `aString` is limited to the value of `aWidth`.

### Arguments

`const TText* aBuf`                      The address of the zero terminated string to be copied and appended.

`TInt aWidth`                            The width of the target area. This must be one of:

    < `KDefaultJustifyWidth`

    < a non-negative value

If it has the value `KDefaultJustifyWidth`, then it is re-set to the length of the zero terminated string (excluding the zero terminator).

If this value is less than the length of the zero terminated string (excluding the zero terminator), then the number of characters copied from `aString` is limited to `aWidth`.

|                    |                                                                                                                       |
|--------------------|-----------------------------------------------------------------------------------------------------------------------|
| TAlign anAlignment | An enumeration which dictates the alignment of the data within the target area. See <a href="#">e32.enum.TAlign</a> . |
| TChar aFill        | The fill character used to pad the target area.                                                                       |

### Notes

If the width of the target area is greater than the maximum length of *this* descriptor, then the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

- Do not set aWidth to a negative value (other than KDefaultJustifyWidth) as this may have unpredictable consequences.

---

### AppendNum()

**Append converted signed integer**

void AppendNum(TInt aVal);

### Description

- Use this function to convert the signed integer aVal into a decimal character representation and append the resulting characters onto the end of the content of *this* descriptor. If the integer is negative, the character representation is prefixed by a minus sign.

### Arguments

TUInt aVal            The value to be converted to decimal characters.

### Example

- The following code fragment illustrates the use of AppendNum().

```
...
TBuf<16> tgt(_L("abc"));    // generates the following strings
TInt numpos(176);           // in the descriptor tgt...
TInt numneg(-176);
...
tgt.AppendNum(numpos);       // "abc176"
tgt.AppendNum(numneg);       // "abc-176"
```

---

### AppendNum(), AppendNumUC()

**Append converted unsigned integer**

[e32.descriptors.TDes.appending.Appendnumusi](#)

```
void AppendNum(TUint aVal,TRadix aRadix=EDecimal);
void AppendNumUC(TUint aVal,TRadix aRadix=EDecimal);
```

## Description

5 Use these functions to convert the unsigned integer aVal into its corresponding character representation and append the resulting characters onto the end of content of *this* descriptor. AppendNum() converts the hexadecimal characters 'a', 'b', 'c', 'd', 'e' and 'f' to lower case. AppendNumUC() converts the hexadecimal characters 'A', 'B', 'C', 'D', 'E' and 'F' to upper case.

## Arguments

|               |                                                                                                                                                                                                |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TUint aVal    | The value to be converted to characters.                                                                                                                                                       |
| TRadix aRadix | The number system representation for the unsigned integer. This is an enumeration; see <a href="#">e32.descriptors.TRadix</a> .<br>If no value is supplied, then EDecimal is taken by default. |

## 10 Example

The following code fragment illustrates the use of AppendNum() and AppendNumUC().

```

...
TBuf<16> tgt_L("abc"));    // generates the following strings
TUint num(176);            // in the descriptor tgt...
15 ...
tgt.AppendNum(num,EBinary); // "abc10101010"
tgt.AppendNum(num,EOctal);  // "abc252"
tgt.AppendNum(num,EDecimal); // "abc176"
tgt.AppendNum(num,EHex);    // "abcaa" <-NB hex value in lower case
20 tgt.AppendNumUC(num,EHex); // "abcAA" <-NB hex value in UPPER case
                                // and current descriptor
                                // content converted to
                                // upper case.
tgt.AppendNum(num);          // "abc176"<--EDecimal taken as default
```

**AppendFormat()****Append converted multiple arguments**

e32.descriptors.TDes.appending.AppendFormat

```
void AppendFormat(TRefByValue<const TDesC> aFmt,...);
```

```
void AppendFormat(TRefByValue<const TDesC> aFmt,
```

```
5      TDesC::Overflow* aOverflowHandler,
      ...);
```

**Description**

Use this function to append formatted text into *this* descriptor, as controlled by the format string supplied in the descriptor aFmt and the argument list which follows it. The generated

10 text is appended to any existing data within *this* descriptor.

The format string contained in aFmt contains literal text, embedded with commands for converting the trailing list of arguments into text.

See the e32.descriptors.format member function for the syntax of the embedded commands.

15 The resulting length of this descriptor must not exceed its maximum length. Once the descriptor reaches its maximum length, any attempt to append more text will result in *one* of the following:

- if aOverflowHandler is *not* supplied, the function panics with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.
- 20 • if aOverflowHandler *is* supplied, the Overflow() member function of *either* TDes8Overflow for the 8 bit variant *or* TDes16Overflow for the 16 bit variant, is called to handle the condition; On return from Overflow(), AppendFormat() completes without panic.

**Arguments**

TRefByValue<const TDesC> aFmt

Any type of descriptor containing the format string. The TRefByValue is constructed from the aFmt.

TDes??Overflow\* aOverflowHandler

If supplied, a pointer to either a TDes8Overflow object (for the 8 bit variant) or a TDes16Overflow object (for the 16 bit variant).

aOverflowHandler->Overflow() is called if an attempt is made to exceed the maximum length of *this* descriptor.

...

A variable number of arguments to be converted to text as dictated by the format string in aFmt.

---

### AppendFormatList()

### Append converted multiple arguments

e32.descriptors.TDes.appending.AppendFormatList

void AppendFormatList(const TDesC& aFmt,

VA\_LIST aList,

5 TDes??Overflow\* aOverflowHandler=NULL);

### Description

This function is equivalent to AppendFormat().

### Arguments

const TDesC& aFmt

A reference to any type of descriptor containing the format string.

VA\_LIST aList

A pointer to a variable number of arguments to be converted to text as dictated by the format string in aFmt.

TDes??Overflow\* aOverflowHandler

If supplied, a pointer to either a TDes8Overflow object (for the 8 bit variant) or a TDes16Overflow object (for the 16 bit variant).  
  
aOverflowHandler->Overflow() is called if an attempt is made to exceed the maximum length of *this* descriptor.

AppendNum()

Append converted floating point number

[e32.descriptors.appendnum-float](#)

TInt AppendNum(TReal aVal,const TRealFormat& aFormat);

Description

5

Use this function to convert the floating point number aVal into a character representation and append the resulting characters onto the end of the content of *this* descriptor.  
  
The format of the character representation is dictated by aFormat, an object of type TRealFormat. See [e32.class.TRealFormat](#) for more information on the TRealFormat class.

10

Arguments

TReal aVal

The floating point number to be converted. The value must be such that  $1.0E-99 \leq |aVal| \leq 1.0E99$ .  
  
Any value smaller than 1.0E-99 is assumed to be zero.

TRealFormat& aFormat

A reference to a TRealFormat object which dictates the format of the conversion.

Return value

TInt

If the conversion is successful, the length of the converted string.  
  
If the conversion fails, a negative value indicating the cause of failure. The possible values and their meaning are as follows:

|               |                                                                                                                                                                                                              |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| KErrArgument  | The length of the converted number is greater than the maximum length of <i>this</i> descriptor. In other words, there is insufficient space in <i>this</i> descriptor to hold the character representation. |
| KErrOverflow  | The number is too large to represent                                                                                                                                                                         |
| KErrUnderflow | The number is too small to represent                                                                                                                                                                         |
| KErrGeneral   | The conversion cannot be completed; e.g. the value of the iWidth member of TRealFormat is too small.                                                                                                         |

---

## Add zero terminator

e32.descriptors.TDes.zero-terminator

---

### ZeroTerminate()

### Append zero terminator

void ZeroTerminate();

#### 5 Description

Use this function to append a zero terminator (i.e. a NULL) onto the end of the content of *this* descriptor.

The length of the descriptor is *not changed*.

#### Notes

- 10 The length of the descriptor must be strictly less than its maximum length otherwise the function will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant. This condition guarantees that there is sufficient space in the descriptor's data area for the zero terminator.

#### Example

- 15 The following code fragment depicted in Figure 19 illustrates the use of ZeroTerminate().

```
...
TBuf<8> tgt(_L("abcde"));
...
tgt.ZeroTerminate()
20 ...
```

The length of the descriptor tgt is 5 both before and after the call to ZeroTerminate()

### Append zero terminator and return a pointer

### Description

5 *this* descriptor and return a pointer to the descriptor's data area.

If the data area only contains text characters, then adding a zero terminator creates a 'C' style zero terminated string.

|              |                                         |
|--------------|-----------------------------------------|
| const TText* | A pointer to the zero terminated string |
|--------------|-----------------------------------------|

The length of the descriptor must be strictly less than its maximum length otherwise the function will panic with `ETDes8Overflow` for the 8 bit variant or `ETDes16Overflow` for the 16 bit variant. This condition guarantees that there is sufficient space in the descriptor's data area for the zero terminator.

## Indexing operators

operator []

## Operator []

### Description

25 as an array of bytes (or double-bytes, but not recommended) of binary data.

These operators allow the individual elements of the array to be accessed and changed.



Two variants of the operator are supplied so that it can return a *lvalue* when applied to a non-const argument or an *rvalue* when applied to a const argument. The decision as to which variant to use, is made by the compiler.

## Arguments

**TInt anIndex**                      The index value indicating the position of the element within the data area. The index is given relative to zero; i.e. a zero value implies the leftmost data position.

This value must be non-negative *and* less than the current length of the descriptor otherwise the operation will panic with `ETDes8IndexOutOfRange` for the 8 bit variant or `ETDes16IndexOutOfRange` for the 16 bit variant

## 5 Return value

**TUint??&**                              A non-const reference to the data at position `anIndex`. The data is of type `TUint8&` for 8 bit variants and of type `TUint16&` for 16 bit variants.

This is returned when the operator is used to return a lvalue.

**const TUint??&**                      A const reference to the data at position `anIndex`. The data is of type `TUint8&` for 8 bit variants and of type `TUint16&` for 16 bit variants.

This is returned when the operator is used to return an rvalue.

The code fragments illustrates the use of operator[].

The code fragments illustrates the use of operator[].

```

...
TBuf<8> str(_L("abcdefg"));

5   TChar ch;

...

str.Length();           // returns 7
ch = str[0];            // ch contains the character 'a'
ch = str[3];            // ch contains the character 'd'

10  ...

str[0] = 'z';           // changes str to "zbcdefg"
str[3] = 'z';           // changes str to "abczefg"

...

ch = str[7];            // Panic !!

15  str[7] = 'z';        // Panic !!

```

## Appending operators

e32.descriptors.TDes.appending-operators

**operator +=**

## Operator +=

```
TDes& operator+=(const TDesC& aDes);
```

## 20 Description

Use this operator to append the content of aDes onto the end of the content of *this* descriptor.

The length of *this* descriptor is incremented by the length of aDes.

## Arguments

|                   |                                                                        |
|-------------------|------------------------------------------------------------------------|
| const TDesC& aDes | A reference to any type of descriptor whose content is to be appended. |
|-------------------|------------------------------------------------------------------------|

## 25 Return value

|       |                                        |
|-------|----------------------------------------|
| TDes& | A reference to <i>this</i> descriptor. |
|-------|----------------------------------------|

## Notes

The operator can only be used by classes derived from TDes, specifically TPtr and TBuf.

The resulting length of *this* descriptor must not be greater than its maximum length otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or

5 ETDes16Overflow for the 16 bit variant

## Example

The following code fragment illustrates the use of this operator.

```

...
TBuf<16> tgt(_L("abc"));
10 ...
tgt+=(_L("0123456789"));    // generates "abc0123456789"
tgt+=(_L("0123456789qwerty")); // Panics !!

```

---

## Non-class specific assignment operators

e32.descriptors.TDes.assignment-operators

15 The behaviour of these operators is exactly the same as the class specific operators. However, unlike the class specific operators, these non-class specific operators are *not* inline.

The compiler invokes these non-class specific assignment operators whenever the left hand variable of an assignment operation is *not* of a concrete type i.e. one of TPtr,

20 TBufC<class S>, TBuf<class S> or HBufC.

For example,

```

class TMyClass
{
public :
25 void MyCopy(TDes& aTarget, TDesC& aSource);
}

```

```

void TMyClass::MyCopy(TDes& aTarget, TDesC& aSource)
{
    aTarget = aSource; // Non-class specific operator used.
}

```

```

5      {
        TBuf<16> target;
        TBufC<16> source(_L("ABCDEF"));

        TMyClass mine;
10
        mine.MyCopy(target,source);

```

If the member function MyCopy is changed so that it is prototyped as:

```
void MyCopy(TBuf<16>& aTarget, TDesC& aSource);
```

15 or even

```
void MyCopy(TBuf<16>& aTarget, TBufC<16>& aSource);
```

then the TBuf<class S> class assignment operator would be used by the compiler.

However, such a change could compromise the design of the class TMyclass.

---

**operator =**

**Operator = taking any descriptor**

20 TDes& operator=(const TDesC& aDes);

### Description

This assignment operator copies the content of any type of descriptor aDes into *this* descriptor.

The content of aDes is copied into *this* descriptor, replacing the existing content. The length of *this* descriptor is set to the length of aDes.

### Arguments

|                   |                                                                      |
|-------------------|----------------------------------------------------------------------|
| const TDesC& aDes | A reference to any type of descriptor whose content is to be copied. |
|-------------------|----------------------------------------------------------------------|

**Return value**

TDes&                      A reference to *this* descriptor.

**Notes**

This assignment operator returns a reference to type TDes, i.e. the base abstract class for modifiable descriptors.

- 5 The length of aDes must not be greater than the maximum length of *this* descriptor otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

---

**operator =**

**Operator = taking a modifiable descriptor**

TDes& operator=(const TDes& aDes);

10 **Description**

This assignment operator copies the content of a modifiable descriptor aDes into *this* descriptor.

The content of aDes is copied into *this* descriptor, replacing the existing content. The length of *this* descriptor is set to the length of *aDes*.

15 **Arguments**

const TDes& aDes              A reference to a modifiable type descriptor whose content is to be copied.

**Return value**

TDes&                      A reference to *this* descriptor.

**Notes**

This assignment operator returns a reference to type TDes, i.e. the base abstract class for modifiable descriptors.

- 20 The length of aDes must not be greater than the maximum length of *this* descriptor otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

**operator =****Operator = taking zero terminated string**

TDes&amp; operator=(const TText\* aString);

**Description**

This assignment operator copies a zero terminated string, excluding the zero terminator,  
 5 into *this* descriptor.

The copied string replaces the existing content of this descriptor.

The length of *this* descriptor is set to the length of the string (excluding the zero terminator).

**Arguments**

const TText\* aString                      The address of the zero terminated string to be copied.

10 **Return value**

TDes&                                      A reference to *this* descriptor.

**Notes**

This assignment operator returns a reference to type TDes, i.e. the base abstract class for modifiable descriptors.

The length of aDes must not be greater than the maximum length of *this* descriptor  
 15 otherwise the operation will panic with ETDes8Overflow for the 8 bit variant or ETDes16Overflow for the 16 bit variant.

---

**TDes8Overflow class****Overflow handler (8 bit)**

---

**Overview****Derivation**

TDes8Overflow                      Abstract: 8 bit variant overflow handler.

20 **Defined in**

e32des8.h

**Description**

A TDes8Overflow derived object is used by the AppendFormat() and AppendFormatList() member functions of 8 bit variant descriptors to handle descriptor overflow.

Overflow occurs if an attempt is made to append text to the descriptor when the descriptor is already at its maximum length.

The class is abstract and defines the pure virtual member function `Overflow()`.

See `e32.descriptors.TDes.appending.AppendFormat` and

5 `e32.descriptors.TDes.appending.AppendFormatList`.

### Writing derived classes

A derived class must provide an implementation for the `Overflow()` member function.

---

## Overflow handling

### Overflow()

### Overflow handler function

10 `virtual void Overflow(TDes8& aDes);`

#### Description

A pure virtual function.

The function is called by the `AppendFormat()` and the `AppendFormatList()` member functions of an 8 bit variant descriptor if an attempt is made to append text to this  
15 descriptor when the descriptor is already at its maximum length.

A derived class must provide an implementation for this function.

#### Arguments

|                              |                                                                                                                    |
|------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <code>TDes8&amp; aDes</code> | A reference to the 8 bit variant modifiable descriptor whose<br>overflow has resulted in the call to this function |
|------------------------------|--------------------------------------------------------------------------------------------------------------------|

---

## TDes16Overflow class

## Overflow handler (16 bit)

---

### Overview

20 **Derivation**

|                             |                                            |
|-----------------------------|--------------------------------------------|
| <code>TDes16Overflow</code> | Abstract: 16 bit variant overflow handler. |
|-----------------------------|--------------------------------------------|

#### Defined in

`e32des16.h`

**Description**

A TDes16Overflow derived object is used by the AppendFormat() and AppendFormatList() member functions of 16 bit variant descriptors to handle descriptor overflow.

- 5    Overflow occurs if an attempt is made to append text to the descriptor when the descriptor is already at its maximum length.

The class is abstract and defines the pure virtual member function Overflow().

See [e32.descriptors.TDes.appending.AppendFormat](#) and [e32.descriptors.TDes.appending.AppendFormatList](#).

10    **Writing derived classes**

A derived class must provide an implementation for the Overflow() member function.

---

**Overflow handling**

---

|                   |                                  |
|-------------------|----------------------------------|
| <b>Overflow()</b> | <b>Overflow handler function</b> |
|-------------------|----------------------------------|

virtual void Overflow(TDes16& aDes);

15    **Description**

A pure virtual function.

The function is called by the AppendFormat() and the AppendFormatList() member functions of an 16 bit variant descriptor if an attempt is made to append text to this descriptor when the descriptor is already at its maximum length.

- 20    A derived class must provide an implementation for this function.

**Arguments**

|              |                                                                                                                  |
|--------------|------------------------------------------------------------------------------------------------------------------|
| TDes16& aDes | A reference to the 16 bit variant modifiable descriptor whose overflow has resulted in the call to this function |
|--------------|------------------------------------------------------------------------------------------------------------------|

---

|                    |                                     |
|--------------------|-------------------------------------|
| <b>TRadix enum</b> | <b>Number system representation</b> |
|--------------------|-------------------------------------|

[e32.descriptors.TRadix](#)

**Defined in**

- 25    e32std.h



**Description**

An enumeration whose enumerators govern the number system representation of signed and unsigned integers when converting them into character format.

The enumeration is used by the descriptor member functions

- 5 [e32.descriptors.TDes.integer-conversion.Numusi](#) and  
[e32.descriptors.TDes.appending.Appendnumusi](#).

**Members**

|          |                                                      |
|----------|------------------------------------------------------|
| EBinary  | Conversion into binary character representation.     |
| EOctal   | Conversion into octal character representation.      |
| EDecimal | Conversion into decimal character representation.    |
| HEX      | Conversion into hexadecimal character representation |

**TAlign enum****Alignment of data****Defined in**

- 10 [e32std.h](#)

**Description**

An enumeration whose enumerators govern the alignment of data within an area. The enumeration is used by the descriptor member functions [e32.descriptors.TDes.copy-justify.justify](#), [e32.descriptors.TDes.appending.appendjustify-anydesc](#),

- 15 [e32.descriptors.TDes.appending.appendjustify-partdesc](#),  
[e32.descriptors.TDes.appending.appendjustify-fromadr](#) and  
[e32.descriptors.TDes.appending.appendjustify-zeroterm](#).

**Members**

|         |                        |
|---------|------------------------|
| ELeft   | Data is left aligned.  |
| ERight  | Data is right aligned. |
| ECenter | Data is centered.      |

---

**\_S macro****Build independent string****Defined in**

e32def.h

**Description**

```

5      #if defined(_UNICODE)
      typedef TText16 TText;
      ...
      #define _S(a) ((const TText *)L ## a)
      #else
10     typedef TText8 TText;
      ...
      #define _S(a) ((const TText *)a)
      #endif

```

**Notes**

15 The definition of \_S in e32std.def is intertwined with the definition of \_L.

---

**\_L macro****Build independent literal****Defined in**

e32def.h

**Description**

```

20     #if defined(_UNICODE)
      typedef TText16 TText;
      #define _L(a) (TPtrC((const TText *)L ## a))
      ...
      #else
25     typedef TText8 TText;
      #define _L(a) (TPtrC((const TText *)a))
      ...
      #endif

```

**Notes**

The definition of `_L` in `e32std.def` is intertwined with the definition of `_S`.

---

**\_S8 macro****8 bit string****Defined in**5 `e32def.h`**Description**

```
#define _S8(a) ((const TText8 *)a)
```

---

**\_L8 macro****8 bit literal****Defined in**10 `e32def.h`**Description**

```
#define _L8(a) (TPtrC8((const TText8 *)a))
```

---

**\_S16 macro****16 bit string****Defined in**15 `e32def.h`**Description**

```
#define _S16(a) ((const TText16 *)L ## a)
```

---

**\_L16 macro****16 bit literal****Defined in**20 `e32def.h`**Description**

```
#define _L16(a) (TPtrC16((const TText16 *)L ## a))
```

---

**Glossary definitions**

| Term | Aliase | Meaning | See Also |
|------|--------|---------|----------|
|------|--------|---------|----------|

**s**

|                       |   |                                                                                                                                                                                                                                                               |
|-----------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>built-in type</b>  | n | Data types which are part of the C++ language; e.g. unsigned int, unsigned char etc                                                                                                                                                                           |
| <b>descriptor</b>     | n | An object capable of representing contiguous data and providing member functions to operate on that data.                                                                                                                                                     |
| <b>huffman encode</b> | v | A process of compressing data.                                                                                                                                                                                                                                |
| <b>huffman decode</b> | v | A process of de-compressing data which was originally compressed using Huffman encoding.                                                                                                                                                                      |
| <b>length</b>         | n | The length of data currently represented by a descriptor.                                                                                                                                                                                                     |
| <b>maximum length</b> | n | The maximum length of data which a modifiable type descriptor is capable of holding.                                                                                                                                                                          |
| <b>fold</b>           | v | The removal of differences between characters that are deemed unimportant for the purposes of inexact or case-insensitive matching. As well as ignoring differences of case, folding ignores any accent on a character.                                       |
| <b>collate</b>        | v | The removal of differences between characters that are deemed unimportant for the purposes of ordering characters into their collating sequence                                                                                                               |
| <b>unicode</b>        |   | ISO 10646-1 defines a “universal character code” which uses either 2 or 4 bytes to represent characters from a large character set. Thus, Far Eastern character sets can be represented.<br><br>In ERA, 2-byte UNICODE support is built deep into the system. |

[illegible]

## Claims

- 5 1. A computing device programmed with an object oriented operating system, in which the operating system is adapted to handle objects related to text strings; characterised in that the operating system handles all such objects as belonging to one of three classes in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.
- 10 2. A peripheral device for a computer programmed with an object oriented operating system, in which the operating system is adapted to handle objects related to text strings; characterised in that the operating system handles all such objects as belonging to one of three classes in which each class performs a different function and at least one such class is
- 15 modified to do so in a way that reduces code and cycle overhead and further characterised in that the peripheral device is programmed to handle objects which also fall into the above three classes.
- 20 3. An operating system for a computer, in which the operating system is adapted to handle objects related to text strings and is encoded on computer readable media; characterised in that the operating system handles all such objects as belonging to one of three classes in which each class is optimised to perform a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.
- 25 4. A method of operating a micro-processor using an operating system, in which the operating system is adapted to handle objects related to text strings; characterised in that the operating system handles all such objects as belonging to one of three classes, in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.

5. Computer readable media encoded with an operating system adapted to handle objects related to text strings; characterised in that the operating system handles all such objects as belonging to one of three classes, in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead.
6. A product or process as claimed above in which objects in one of the three classes are also pointers.
7. A product or process as claimed in claim 6 in which a pointer points to the original memory location of literal text.
8. A product or process as claimed in Claim 6 in which such an object is a flat structure.
9. A product or process as claimed above in which objects in one of the three classes (other than objects to which claims 6 - 8 relate) handle length limited text.
10. A product or process as claimed in claim 9 in which those objects handling length limited text are serviced by a limited sub-set of the potentially available memory management functions.
11. A product or process as claimed in claim 10 in which those objects handling length limited text use static memory.
12. A product or process as claimed in claim 9 in which those objects handling length limited text are flat structures.

13. A product or process as claimed above in which objects in one of the three classes (other than objects to which claims 6 - 12 relate) use heap memory and require the full set of available memory management functions.

5 14. A product or process as claimed in any of Claims 1 - 13 above in which objects in any of the three classes are polymorphic.

15. A product or process as claimed in claim 14 in which polymorphism is achieved in one instance by virtue of the operating system including a function that looks to a  
10 predetermined field within each object and, depending on the value in that field, leads to a different kind of behaviour.

16. A product or process as claimed in claim 15 above in which the field shares a machine word with another data item.

15

17. A product or process as claimed in any of Claims 1 - 16 above which is written in 8 bit character set and 16 bit character set invariant form by using aliases for class names that are 8 bit character set and 16 bit character set invariant.

20

18. A product or process as claimed in any of Claims 17 above which is written in ASCII and Unicode invariant form by using aliases for class names that are ASCII and Unicode invariant.

19. A product or process as claimed in any of Claims 1 - 18 above in which objects in  
25 any of the three classes are inherently length specified and hence have no '0' terminator.



## Abstract

5 Operating System for a Computer Based on C++ Programming Techniques

An object oriented operating system handles all objects related to text strings as belonging to one of three classes, in which each class performs a different function and at least one such class is modified to do so in a way that reduces code and cycle overhead. This reduces executable code overhead to minimise the amount of memory required, and allows execution in a minimum number of cycles to minimise power consumption. The operating system is particularly well suited to ROM based mobile computing devices.

15

Accepted for publication

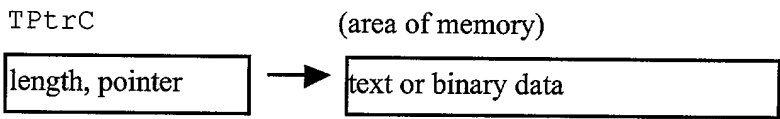


Figure 1

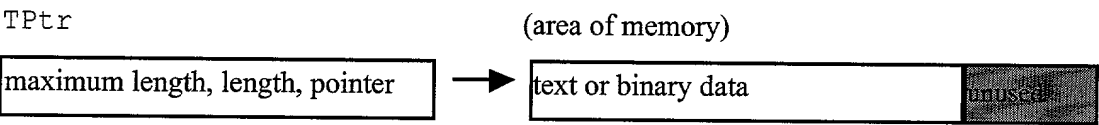


Figure 2A

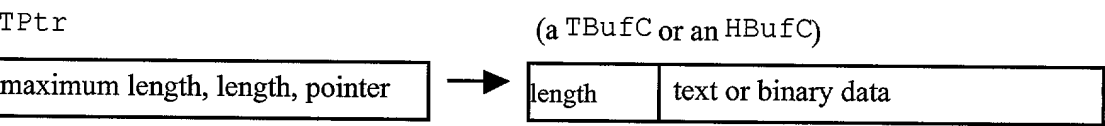


Figure 2B

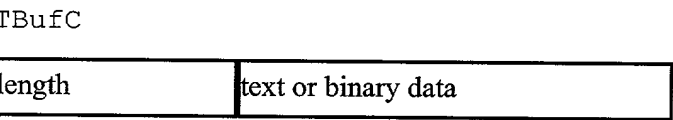


Figure 3

DocId:33944300

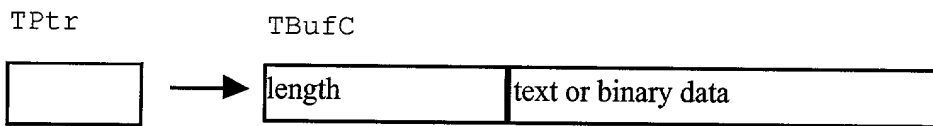


Figure 4

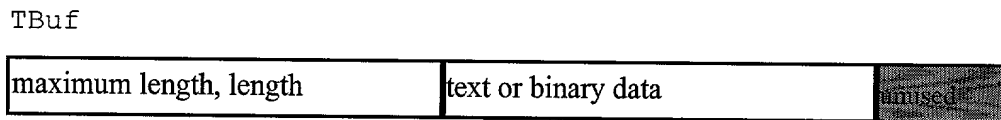


Figure 5

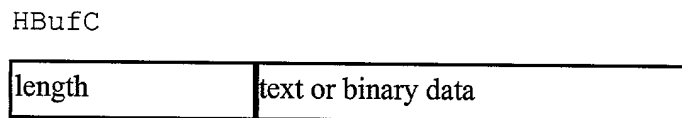


Figure 6

Approved for Release by NSA on 09-11-2013 pursuant to E.O. 13526

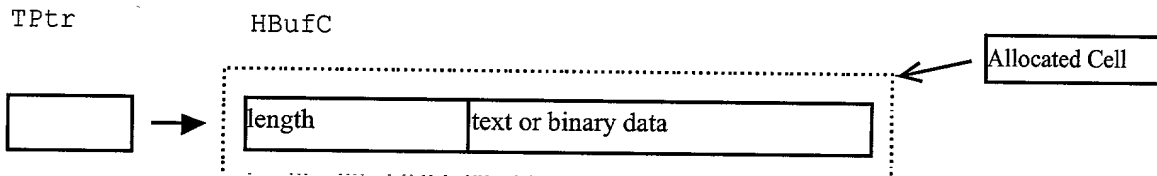


Figure 7

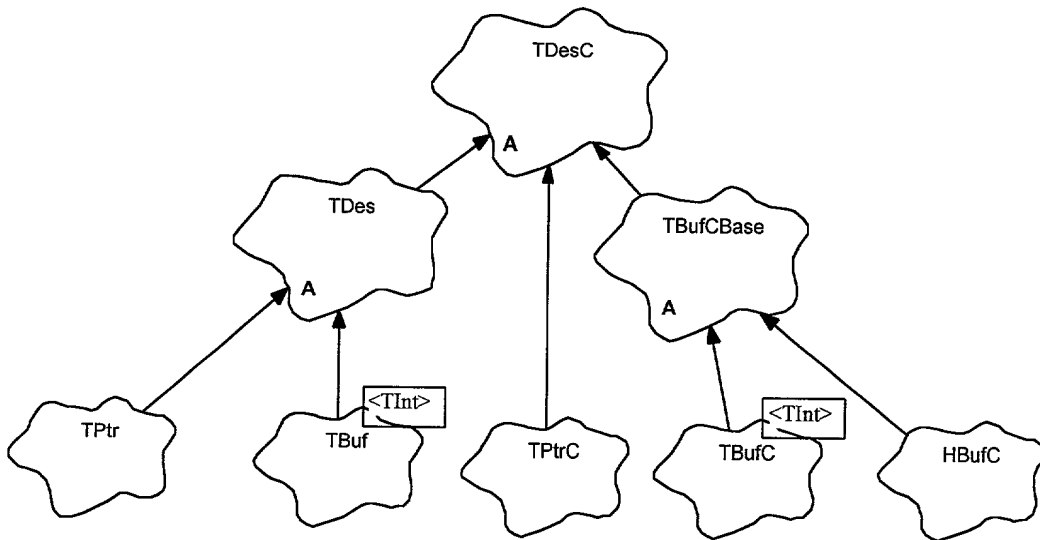


Figure 8

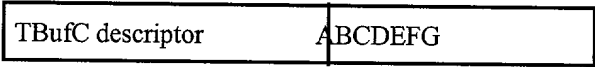


Figure 9

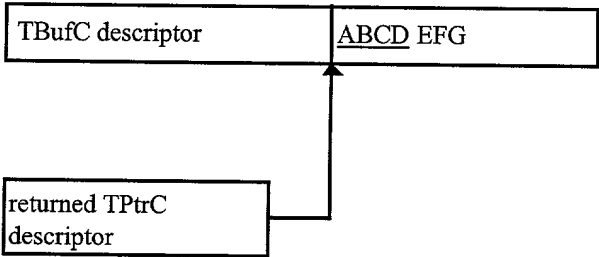


Figure 10



Figure 11

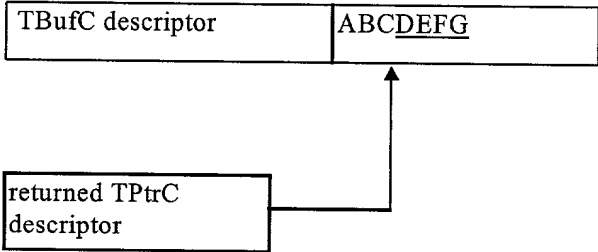


Figure 12

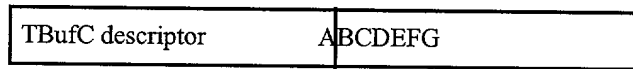


Figure 13

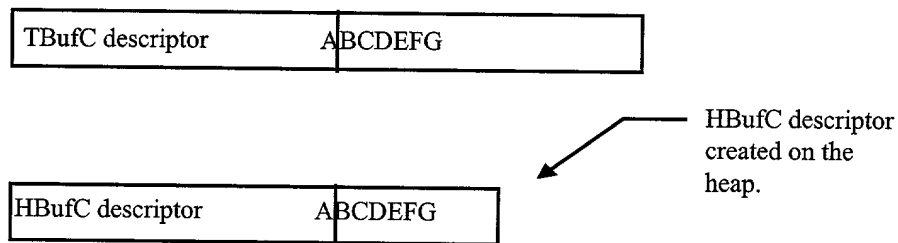


Figure 14

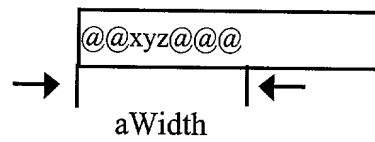


Figure 15

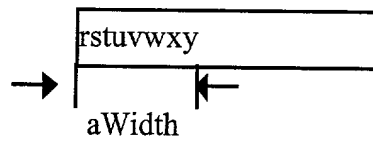


Figure 16

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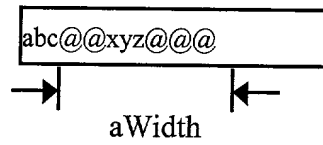


Figure 17

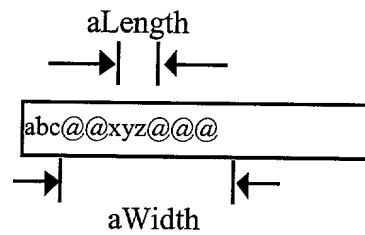
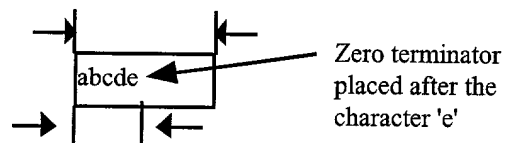


Figure 18

Maximum length is 8



Length of data is 5

Figure 19

Page 1

Attorney's Docket No. OR11.01APC**DECLARATION - USA PATENT APPLICATION**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled OBJECT ORIENTED OPERATING SYSTEM

the specification of which:

- (a) ☐ is attached hereto; or
- (b) ☐ was filed on \_\_\_\_\_ as ☐ Application No. 0 / \_\_\_\_\_ or ☐ Express Mail No., as Application No. not yet known \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable); or
- (c) ☒ was described and claimed in PCT International Application No. PCT/GB98/01717 filed on June 12, 1998.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above;

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, § 1.56;

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent, design or inventor's certificate or of any PCT international application(s) listed below and have also identified below any foreign application(s) for patent, design or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed for the same subject matter having a filing date before that of the application of which priority is claimed:

**PRIOR FOREIGN APPLICATION(S)**

| COUNTRY (OR INDICATE IF PCT) | APPLICATION NUMBER | DATE OF FILING (day, month, year) | PRIORITY CLAIMED UNDER 37 U.S.C. § 119                              |
|------------------------------|--------------------|-----------------------------------|---------------------------------------------------------------------|
| Great Britain                | 9712455.6          | 13, June, 1997                    | <input checked="" type="checkbox"/> YES NO <input type="checkbox"/> |
|                              |                    |                                   | <input type="checkbox"/> YES NO <input type="checkbox"/>            |
|                              |                    |                                   | <input type="checkbox"/> YES NO <input type="checkbox"/>            |
|                              |                    |                                   | <input type="checkbox"/> YES NO <input type="checkbox"/>            |
|                              |                    |                                   | <input type="checkbox"/> YES NO <input type="checkbox"/>            |

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below, and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:



PATENT

ESTABLISHMENT OF RIGHT OF ASSIGNEE TO TAKE ACTION  
AND  
REVOCATION AND POWER OF ATTORNEY

To the Commissioner of Patents and Trademarks:

The undersigned is empowered to act on behalf of the assignee indicated below (the "Assignee"). The original assignment of the attached application for Letters Patent for the invention in OBJECT ORIENTED OPERATING SYSTEM

from the inventors to the Assignee is being submitted herewith for recordation by the Assignment Branch. A true copy of this Assignment is attached hereto. This Assignment represents the entire chain of title of this invention from the Inventor(s) to the Assignee. I have reviewed this Assignment, and to the best of the Assignee's knowledge and belief, the Assignee is the owner of the entire right, title, and interest in the above-referenced application.

I declare that all statements made herein of my own knowledge are true, and that all statements made upon information and belief are believed to be true, and further, that these statements were made with the knowledge that willful, false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001, and that willful, false statements may jeopardize the validity of the application, or any patent issuing thereon.

The undersigned hereby revokes any previous powers of attorney in the subject application, and hereby appoints the registrants of Knobbe, Martens, Olson & Bear, LLP, 620 Newport Center Drive, Sixteenth Floor, Newport Beach, California 92660, Telephone (949) 760-0404, Customer No. 20,995, as its attorneys with full power of substitution and revocation to prosecute this application and to transact all business in the U.S. Patent and Trademark Office connected herewith. This appointment is to be to the exclusion of the inventor(s) and his attorney(s) in accordance with the provisions of 37 C.F.R. § 3.71.

Please use Customer No. 20,995 for all communications.

Assignee: Symbian Limited

By: [Signature]

Title: Managing Director

Address: 19 Harcourt Street  
London W1M 1DT  
United Kingdom.

Dated: 11 Feb 99

OOP-1082-46  
011999

Page 2

Attorney's Docket No. OR11.01APCPrior U.S.A. Application(s)

Application No.: \_\_\_\_\_ Filing Date: \_\_\_\_\_ Status: \_\_\_\_\_

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful, false statements may jeopardize the validity of the application or any patent issued thereon.

1-08 Full name of sole or first inventor: Nicholas Simon MyersInventor's signature [Signature] Day 11 Month Feb Year 2001Residence (city and country): 247 Goldhurst Terrace, London NW6 3EP, Great Britain GBCitizenship: ZimbabwePost Office Address: Same As Above

Full name of second inventor: \_\_\_\_\_

Inventor's signature \_\_\_\_\_ Day \_\_\_\_\_ Month \_\_\_\_\_ Year \_\_\_\_\_

Residence (city and country): \_\_\_\_\_

Citizenship: \_\_\_\_\_

Post Office Address: \_\_\_\_\_

Full name of third inventor: \_\_\_\_\_

Inventor's signature \_\_\_\_\_ Day \_\_\_\_\_ Month \_\_\_\_\_ Year \_\_\_\_\_

Residence (city and country): \_\_\_\_\_

Citizenship: \_\_\_\_\_

Post Office Address: \_\_\_\_\_

Send Correspondence To:

KNOBBE, MARTENS, OLSON &amp; BEAR, LLP

Customer No. 20,995

OOP-(08)-46  
01/999